

PHILOSOPHICAL TRANSACTIONS.

I. THE BAKERIAN LECTURE.—*On the Proofs of a gradual Rising of the Land in certain parts of Sweden.* By CHARLES LYELL, Jun. Esq. F.R.S.

Received October 4,—Read November 27, 1834.

IT is now more than one hundred years since the Swedish naturalist CELSIUS expressed his opinion that the waters, not only of the Baltic, but of the whole Northern Ocean, were gradually sinking; and he represented their level as lowering at the rate of forty Swedish inches in a century*. He observed that several rocks which not long ago were sunken reefs and dangerous to navigators, had become in his time above water; that the sea was constantly leaving dry new tracts of land along its borders; that ancient ports had become inland towns; and that old fishermen and seafaring people could testify that at a variety of places, both on the shores of the Baltic and the ocean, considerable changes had taken place within the time of their memory, in the form of the coast and depth of the sea. Lastly he appealed to marks which had been cut in the rocks before his time expressly to indicate the former level, and the waters were observed to have fallen below these marks.

This notion of a change continually in progress in the relative level of land and sea was at first warmly controverted, and many facts were adduced to prove that there had not been a general fall of the waters even in the Baltic. It was supposed by many that there might have been some error in the observations, as the Baltic, though free from tides, is often raised for several days continuously two or three feet above its standard level by the melting of the snow, or by the prevalence of particular winds; and it was remarked that the altered form of the coast and the shallowing of the sea might be ascribed partly to new accessions of land at points where rivers entered, depositing sand and mud, and partly to the drifting of large blocks by ice, which are sometimes stranded and driven up on rocks and low islands so as to raise their height.

PLAYFAIR, in the year 1802, in his “Illustrations of the Huttonian Theory,” de-

* I have used the Swedish measure throughout this paper, for the sake of uniformity, when alluding to the measurements made by Swedes. The Swedish foot, which is divided into twelve inches, agrees very nearly with our own, being less than ours by three eighths of an inch only.

clared that the supposed change of relative level of sea and land in Sweden, which appeared to him to be sufficiently ascertained, might be ascribed to the movement of the land rather than of the waters. He observed, "that in order to depress or elevate the absolute level of the sea, by a given quantity, in any one place, we must depress or elevate it by the same quantity over the whole surface of the earth; whereas no such necessity exists with respect to the elevation or depression of the land*." The hypothesis of the rising of the land, he adds, "agrees well with the Huttonian theory, which holds that our continents are subject to be acted upon by the expansive forces of the mineral regions; that by these forces they have been actually raised up, and are sustained by them in their present situation†."

In the year 1807 VON BUCH, after returning from a tour in Scandinavia, announced his conviction "that the whole country from Frederickshall in Sweden to Åbo in Finland, and perhaps as far as St. Petersburg, was slowly and insensibly rising;" a conclusion to which he appears to have been led principally by information obtained from the inhabitants, and in part by the occurrence of marine shells, of recent species, which he had found at several points on the coast of Norway above the level of the sea.

At several periods since this discussion began respecting the decline of the level of the Baltic Sea and German Ocean, marks have been cut on the rocks of exposed cliffs, both of islands and the main land, so as to indicate the then existing height of the waters, the year in which the marks were made being at the same time recorded. All these marks were examined in 1820–21 by the officers of the pilotage establishment of Sweden, and a report made by them to the Royal Academy at Stockholm, in which they declared, as the result of their measurement, that along the whole coast of the northern part of the Gulf of Bothnia the water is lower with respect to the land than formerly; but that the amount of variation, or change of level, has not been uniform. At the same time an account was given in, and published by the Academy, of new marks which were made in the same years, 1820–21, to record the level of the sea observed at the time of the survey.

Notwithstanding the numerous proofs recorded of the change of level, and the high authorities who had declared in its favour, I continued, in common with many others, to entertain some doubts respecting the reality of the phenomenon, partly because I suspected that it might be explained by reference to more ordinary causes, such as some of those above mentioned, and partly because it appeared to me improbable that such great effects of subterranean expansion should take place in countries which, like Sweden and Norway, have been remarkably free within the times of history from violent earthquakes. The slow, constant, and insensible elevation of a large tract of land, is a process so different from the sudden rising or falling known to have accompanied, in certain regions, the intermittent action of earthquakes and volcanos, that the fact appeared to require more than an ordinary weight of evidence for its confirmation. I am willing, however, to confess, after

* § 393.

† § 398.

reviewing all the statements published previously to my late tour for and against the reality of the change of level in Sweden, that my scepticism appears to have been unwarrantable; but it will not be disputed that too many proofs cannot be accumulated to substantiate so remarkable a phenomenon.

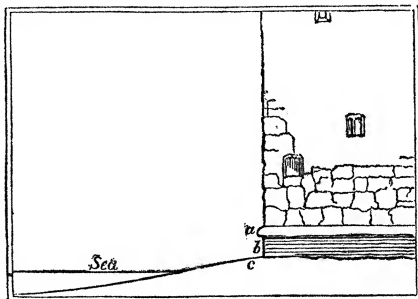
I propose, therefore, to lay before the Royal Society the observations which I made during the summer of 1834, with a view of satisfying myself in regard to the data appealed to in support of the elevation of parts both of the eastern and western shores of Sweden. As much of the evidence could only have been derived from personal intercourse with the inhabitants, it may be proper to mention that I was accompanied throughout my excursion by a well-informed Swede, Mr. JOHNSON, who by his thorough knowledge of the English language was well qualified to assist me as interpreter.

On my way to Sweden I examined the eastern shores of the Danish islands of Möen and Seeland; but neither there, nor afterwards in Scania, could I discover any signs of a recent upward movement of the land, nor could I learn that the notion of such a change was entertained by the natives. Proceeding northwards along the coast of the Baltic, the first place which I visited where any elevation of land is supposed to be going on was Calmar. This port is situated in latitude $56^{\circ} 41'$. To the south of the town is the celebrated ancient castle in which was signed, in the year 1397, the famous treaty of union between Sweden, Denmark, and Norway. The castle is supposed to have remained in its present state from a still earlier period. There was a fortress on the site so long ago as the year 1030*. Two round-towers terminate the outworks of this fortress on the side of the sea; and when I observed that the base of one of these rested on the beach only two feet above the level of the water, and when I found that sea-weed had recently been washed up, so as to touch the lowest part of the building, I concluded, at first, that for the last four or five centuries there could have been no lowering of the Baltic at this place, for otherwise

we should be compelled to suppose that part of the tower had been originally constructed under water. But on nearer inspection I was led to suspect that this had really been the case, and that the foundation was originally subaqueous. At the height of about two feet above the base of the tower (see sketch, fig. 1.), and four feet above the level of the sea, a projecting band of stone (*a*), one foot deep, encircles the tower like a hoop. This projecting band is of smooth stone, and the stones above it are large, and with an even, dressed surface. But below the hoop are many courses of thin slabs of a different stone (*b*), with layers of cement between. It oc-

Fig. 1.

Part of one of the round-towers of Calmar Castle.



a, Projecting band or hoop of stone; *b*, thin layers of slabs of stone and mortar, originally perhaps built under water; *c*, the beach covered by water when the sea is high.

of thin slabs of a different stone (*b*), with layers of cement between. It oc-

* See ANKARSVARD'S Work on Calmar Castle.

curred to me that these rough slabs and cement may have been laid originally under water, and that the projecting rim of dressed stone may have formed the visible base of the building, which now rises to the height of about twenty-five feet above. This idea is rendered the more probable, as it is known that the castle had often defended itself from attacks on the side of the sea. I have since been informed by our eminent architect Mr. WILKINS, that it is highly probable, from the general analogy of buildings having a subaqueous foundation, that the courses of slaty stone were laid under water, and that the projecting fascia was alone intended to be seen above the level of the sea. Admitting this conjecture to be well founded, it would still prove that there has been a much slighter rise of the land since this building was erected, or during the last four centuries and upwards, than some writers have imagined, for it cannot have amounted to more than four feet in that time. Part of the moat on one side of the castle, which is believed to have been formerly filled with water from the sea, is now dry, and the bottom covered with green turf. It may have been in part silted up with sand and sediment, but a slight rise of the land would have contributed to its desiccation. A garden, composed of newly gained land in the harbour, between the castle and the town, in a place where there was sea half a century ago, clearly shows that the deposition of sedimentary matter may sometimes take place rapidly on this coast.

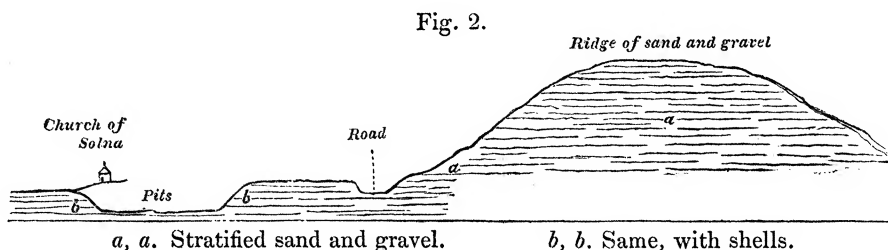
From Calmar I went to Stockholm, where I immediately found many striking geological proofs of a change in the relative level of land and sea, since the Baltic was inhabited by the same species of *Testacea* which it now supports.

The country around Stockholm is in general low, seldom rising to more than 150 feet above the level of the sea, the fundamental rocks being gneiss and granite, which are often quite bare, presenting a surface for the most part smoothed and rounded, as if these rocks had formed for a long time the bottom of the sea, and had been worn and almost polished by the continual attrition of sand and pebbles. A mass of shingle and sand, here and there passing into loam, occasionally covers the rock; but it is rarely of great thickness, excepting along certain lines, where remarkable ridges of sand and gravel are seen, called in Sweden sand-oasar (*åsar*), the term 'oas' in Swedish corresponding to 'rigging' in Scotch, and for which we have no precise English synonym. These oasar are immense banks of sand, from fifty to several hundred yards broad, and from fifty to more than one hundred feet in height, which may often be traced in unbroken lines for a great many leagues through the country, but are breached occasionally by narrow transverse valleys. They usually run in a direction from north to south; generally terminate on both sides in a steep slope, and are sometimes so narrow at the top as to leave little more than room for a road. As they afford excellent materials for road-making, a great many of the highways in Sweden are carried either along the summit or base of these ridges, so that the traveller has many opportunities of observing their form and structure. In places where they are composed of large rounded boulders, of about the size of a man's

head, no stratification is observable; but where, as is more usual, they consist of gravel and fine sand, they are invariably stratified, in the same manner as sand and gravel in the beds of rivers. A great succession of thin layers repose one upon another, often at high inclinations. But this disposition can only be seen where there is a fresh section made in digging for gravel, the materials being so loose as to fall down and soon form a sloping talus.

I shall offer, in another place, some speculations on the probable origin of these ridges; and I have merely alluded to them now in order to explain the position of some fossil shells which I am about to describe. I had learnt from Professor NILSSON, of Lund, a gentleman well known to geologists by his valuable work on the fossils of Scania, that marine shells of species similar to those in the Baltic had been found near Stockholm; and soon after my arrival I was taken to the spot by Professor BERZELIUS. They occur at Solna, about a mile to the north-west of the city, at the foot of one of the great ridges of sand and gravel before mentioned; a ridge which, passing southward, traverses the city of Stockholm, and is said to have afforded fossil shells in the large pits at the Skantstull, in the southern suburbs.

The annexed section will show that there is little more than space for the road between the ridge and the gravel-pits at Solna.



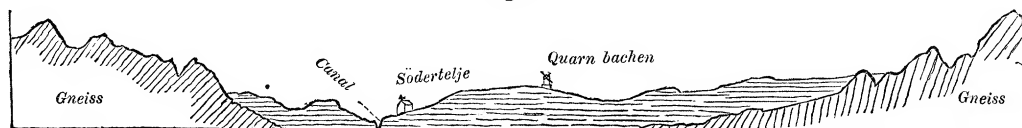
These pits lie between the church of Solna and the public cemetery of Stockholm. Both in the pits and in the adjoining ridge the gravel and sand is stratified, and in general no organic remains can be discovered in them; but in the pits, a little below the level of the road, there are some layers of loam mixed with vegetable matter, where shells occur in abundance. They consist principally of *Cardium edule* and *Tellina Baltica*, a great number of which have both valves united. Portions of the *Mytilus edulis* also occur; and there has evidently been a great accumulation of this shell in the stratum, but it is almost entirely decomposed, and is only recognized by the violet colour which it has imparted to the whole mass. The other shells which I found are, *Littorina crassior*, also the Common Periwinkle (*Littorina littorea*), and a small *Paludina* allied to, if not identical with, our English *Paludina ulva* (see Plate II. fig. 5.). The *Mytilus* and *Cardium* are all dwarfish in size, just as they are found in the brackish water of the neighbouring Gulf of Bothnia, and the whole assemblage of shells is such as characterizes the Baltic. The bed containing them has been ascertained by Colonel HÄLLSTROM to be thirty feet above the level of the Baltic;

so that they afford a clear indication of a change in the relative level of that sea to the amount of thirty feet since its waters were inhabited by the existing species of *Testacea*. On inquiring whether any other examples had been observed of similar deposits of shells, I was informed by Colonel HÄLLSTROM that he had discovered them on the farm of Orby, near Bränkyrka, about three miles to the south of Stockholm. He obligingly accompanied me to the spot, where I found strata of marl and sand filling the bottom of a valley situated in a broken tract of ground where the fundamental rock is gneiss. This tract of land intervenes between Lake Maeler and the sea.

The shells are very numerous, and are for the most part imbedded in a peaty soil containing fragments of wood. The peat has perhaps been derived from sea-weed, large accumulations of which I saw recently heaped up in a bay of the Baltic near Sölvitzborg, intermixed with similar species of shells. The identity of the shells of Bränkyrka with those of the neighbouring sea was even more complete than at Solna; for in addition to the species before enumerated, I found the *Neritina fluviatilis*, a freshwater shell which lives in abundance in the brackish waters of the Baltic, and which I saw covering the rocks in the saltish water at Gräsö, near Oregrund. The Baltic variety is small, and usually black; but both in the recent and fossil individuals it sometimes exhibits its usual variety of colours. Some specimens also of a land shell (*Bulimus lubricus*) occurred with the marine at Bränkyrka.

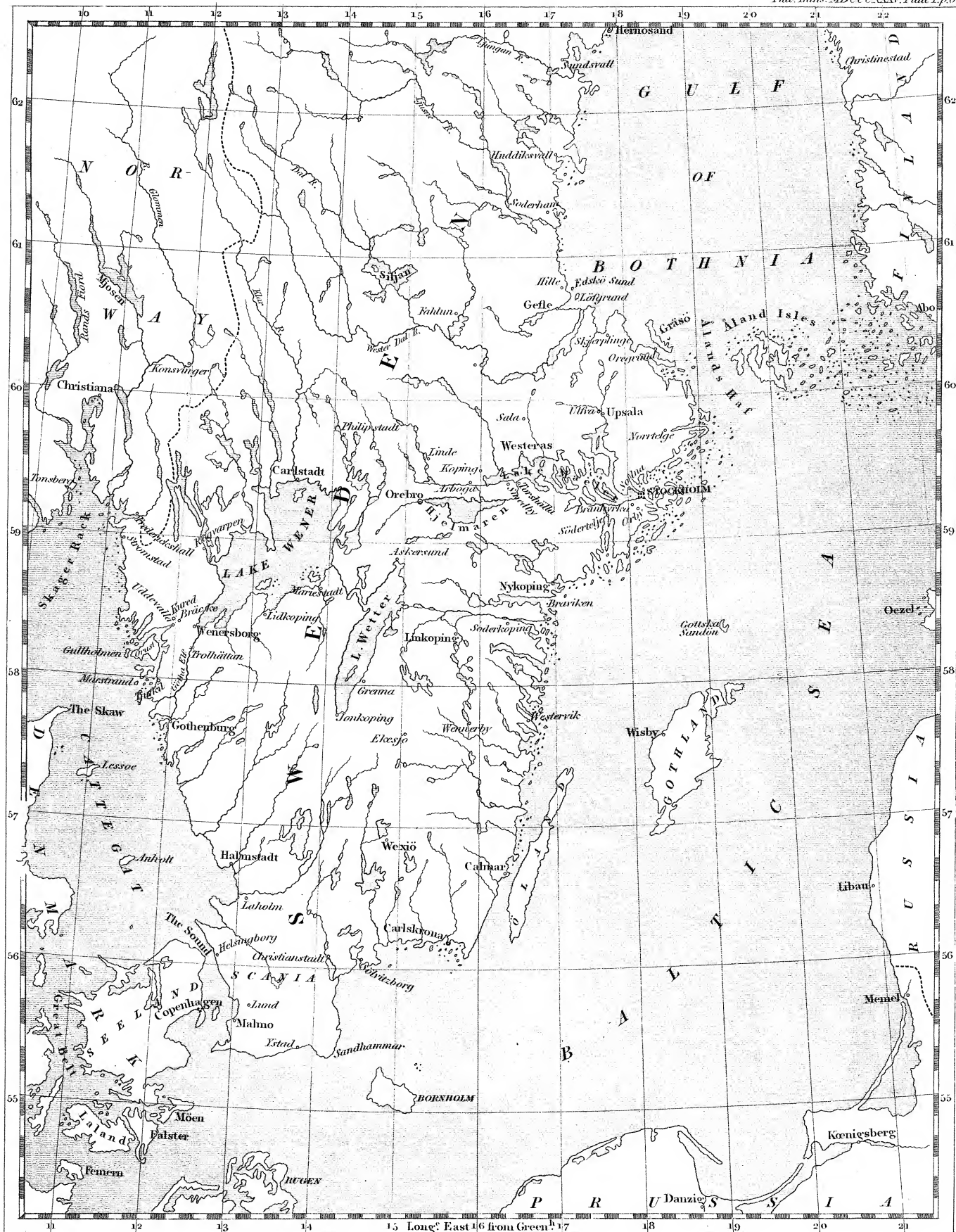
The height of these shells has been determined by Colonel HÄLLSTROM to be seventy Swedish feet above the Baltic; so that they indicate a fall of the waters, or rather a rise of the land, to that amount, since the neighbouring gulf was inhabited by this assemblage of *Testacea*. But the most remarkable spot where these Baltic shells occur in a fossil state is still further to the south, at Södertelje (see the Map, Plate I.), about sixteen miles south-west of Stockholm, where they are found elevated more than ninety feet above the sea. At Södertelje a canal was cut in 1819 across a barrier of sand, gravel, and clay, which separated Lake Maeler from a long narrow inlet or frith of the Baltic. The canal is, in fact, carried through the bottom of one of those valleys so common in this district, of which the sides consist of rocks of gneiss, and the bottom of the same covered by more recent deposits. The accompanying transverse section (fig. 3.) will explain this geological structure.

Fig. 3.



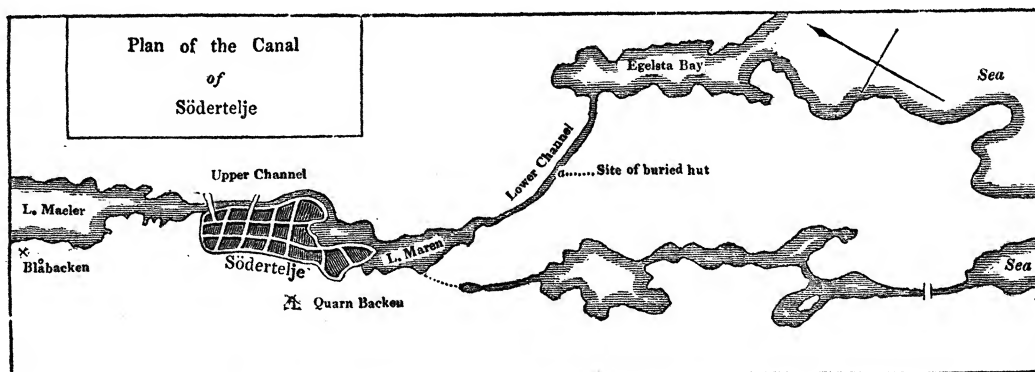
Section across the valley of Södertelje, showing the position of the new deposits in relation to the gneiss.

The boundary hills of bare rock rise to the height of two hundred feet, the newer formation being in some places about one hundred feet high, while on others, as on the site of the Lake Maren, there are hollows which sink beneath the level of the sea.



In these recent strata of loam, sand, and gravel, marine shells have been found at various altitudes, as may be seen by Colonel NORDEWALL's paper in the Transactions of the Royal Academy, where a ground plan is given of the canal and the surrounding district, of part of which I subjoin a reduced copy*. I found at the Quarnbacken (see diagram, fig. 4.), at the height of about ninety feet above the level of the sea, the same species of shells as those at Solna before mentioned, imbedded in a marly clay, which derives a violet colour from the decomposition of the *Mytilus edulis*. Again, the same assemblage of shells may be seen in the Blåbacken, or "blue hills," a neighbouring locality, where a bed of marl about three feet deep rests on the gneiss at the height of about one hundred feet above the sea. Here the violet colour of the decomposed *Mytilus edulis* is so remarkable as to have given a name to the hill. The shells, with the exception of the *Mytilus*, are in general very entire. The breadth of the Södertelje valley, between the opposite boundaries of gneiss, varies from about half to three quarters of a mile; and the newer shelly deposit, which sometimes constitutes a nearly level platform, at the height of sixty feet or more above the canal, has precisely the appearance of the Subapennine formations in Italy, or at the base of the Maritime Alps, where they are seen at inferior elevations, filling the bottom of valleys in the older rocks, or flanking hills of higher antiquity and of inclined stratification. It is only by aid of the shells so exactly corresponding to those of the Baltic that the geologist can at once decide on the comparatively modern origin of these Swedish strata.

Fig. 4.



The distance between the nearest points of Lake Maeler and the sea, now united by the Södertelje canal, is nearly a mile and a half English, the general line of the canal being from north-west to south-east, and the depth of the strata cut through varying from fifteen to more than sixty feet.

First a communication was made which united Lake Maeler with the small lake, or mere, called Maren (see plan); and this passage was called the upper channel. Here a horizontal bed of marl was passed through, of a violet colour, like that of the

* Kongl. Vetenskaps-Academiens Handlingar, 1832.

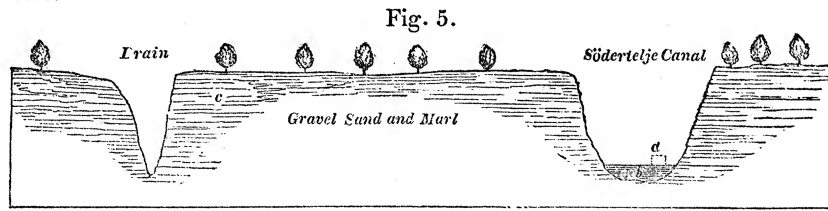
Blåbacken, and containing the *Cardium edule*. Besides the shells, several buried vessels were found in this channel, some of them apparently of high antiquity, there being no iron in them, and the planks being fixed together by wooden pegs. In another place, however, an anchor was dug up, as also, in one spot, some iron nails. In the lower channel, or that which united Lake Maeler with the bay of the sea called Egelsta Wiken, two similar beds of marine shells were found, one at the height of eighteen and the other of forty Swedish feet above the level of the sea.

But a much more remarkable discovery was made in the lower channel. Here the excavation commenced in a hill, or platform, covered with a forest; and after digging down about fifty feet through stratified sand, gravel, and clay, they came upon what appears to have been a small wooden house, the site of which is marked on the plan *a*, fig. 4. The floor of this building was on a level with the sea. Colonel NORDEWALL has stated in his account, that the mass which covered the house was thirty-four feet thick: but he perhaps wrote ells (a Swedish ell is two feet); for Captain CRONSTRAND, an engineer who superintended the whole excavation, and who accompanied me to the spot, assured me that it was at the depth of about sixty-four feet. In other respects this engineer's account agrees with that of Colonel NORDEWALL; but he has enabled me to add some particulars, which I shall now mention.

The stratification of the mass over the house was very decided, but for the most part of that wavy and irregular kind which would result from a meeting of currents. It contained here and there very coarse gravel, and some boulders of considerable size. At the bottom of the whole, a mass of very fine sand was entered, in which the appearance of the four walls of a square building was discovered. Attention was not paid to this phenomenon soon enough to decide whether there were any remains of a roof. An attempt was made to dig round the walls, and leave them standing; but the wood was perfectly decomposed, and crumbled down like dust when all support was removed. But when they reached the level of the sea they found the timber of the walls preserved. At the bottom, on what may have constituted the floor of the hut, an irregular ring of stones was found, having the appearance of a rude fireplace, and within these was a heap of charcoal and charred wood. On the outside of the ring was a heap of unburnt fir-wood, broken up as for fuel, the dried needles of the fir and the bark of the branches being still preserved. The building was about eight feet square, and was supposed to have been merely a fishing-hut, occasionally resorted to at the fishing-season. Captain CRONSTRAND says that the building was enveloped with sand as fine as if blown by the wind.

I visited the nearest spot at which shells were found, in a deep drain not far from the former site of the fossil house, (see plan, fig. 5.) and am satisfied, from their position and from the occurrence of shells at different spots and heights in excavating the "upper channel," that the strata which covered the house, like all the rest cut through by the Södertelje canal, were marine. It appears evident, therefore, that this building must have been submerged beneath the waters of the Baltic to the

depth of sixty-four feet ; and before it was raised again to its present position, which is about even with the level of the sea, it had become covered with strata more than sixty feet thick.



a. Site of the buried hut. b. Water in the canal. c. Bed of violet-coloured marl with *Cardium edule*.

If the buried vessels alone had been found, we should merely have been called upon to suppose that they had sunk to the bottom of a fiord, which was afterwards silted up and then upraised ; but the situation of this house seems to require far greater changes of level. Had nothing been observed but the wooden walls, we might have imagined that the hut was carried away during an inundation, for I was told of a house that was floated off entire during a flood, in the north-east of Sweden, in consequence of the artificial drainage of a lake. But the fireplace and charred wood on the floor seem entirely opposed to such an hypothesis. To imagine a subsidence of the land to the amount of more than sixty feet, and a subsequent elevation, or in other words a series of movements analogous to those by which the phenomena of the Temple of Serapis have been explained, appears necessary ; yet this is undoubtedly to assume far greater revolutions in the level of the land, since fishing-huts were first erected in Sweden, than history or tradition would have led us to anticipate. As to the fine sand in which the house was enveloped, it may be compared to the sand which is known to collect rapidly and form a mound over wrecked vessels which have sunk and presented an obstacle to a marine current charged with sediment.

I ought to state that I was unable to examine the remains of the house, since it was entirely cut away, having stood, as will be seen by the section (fig. 5.), in the exact line of the canal, the surface of the waters of which, like the foundation of the house, were situated at about the mean level of the sea ; for Lake Maeler and the Baltic are so nearly on a level, that when the Baltic rises two or three feet above its mean height, the same lock at Södertelje which usually serves to convey vessels from the Baltic up into Lake Maeler, is used to convey them up in a contrary direction from the lake into the sea. But although I could not see the relic of the fishing-hut itself, I may observe that I had the advantage of conversing with the two eminent engineers who were witnesses to the fact, and who, being greatly astonished at the discovery, took careful notes of the phenomena at the time. They at first conceived that the building might have been part of some well, although this seemed highly improbable, not only from the size of the wooden structure, but from the occurrence of springs at the surface in the immediate neighbourhood. It was only when the fire-

place was found that they could form no other opinion than that it had been a human habitation. In order to explain the position of beds of shells at various heights in the strata intersected by the canal, an hypothesis was suggested by Colonel NORDEWALL, in his published report, that Lake Maeler may once have been shut out from the sea by a high barrier. Sand, gravel, and shells may then have been deposited at its bottom, which on the subsequent removal of the barrier were left at their present height above the lake. But if the shells had been submitted to a conchologist, they would have been at once recognized as consisting for the most part of marine species, such as do not exist in the present waters of Lake Maeler, but are characteristic of the Baltic. Whatever doubts, therefore, may hang over the causes which brought the hut into the extraordinary position in which it was discovered, it is impossible to reflect on this and the other facts brought to light during the excavation of the Södertelje canal, without being convinced that very important movements have taken place in the land and the bed of the sea since the Baltic was inhabited by the existing *Testacea*, and even since the sea was navigated by vessels, and this country inhabited by man.

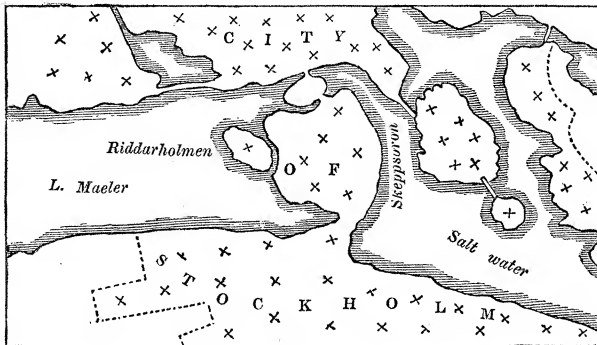
In regard to the shells, I may observe that the *Mya arenaria* is the only one found by me in great abundance in any part of the Baltic which I did not see among the fossils of any of the localities already mentioned, or those afterwards to be alluded to, further to the north. But this shell does not, I believe, extend so far north in the Gulf of Bothnia as Södertelje; I could not find it even at Calmar, and further south, at Sölvitzborg, it was rare, and of very small size. The analogy, in fact, of the fossil shells to those now living in the Bothnian Gulf is most complete: the shells are the same species, partly freshwater and partly marine, the species taken collectively being few in number, and the marine attaining a smaller average size than in the ocean, where the water is more salt. The *Tellina Baltica* is everywhere in great abundance. Hence we may conclude, that since the time when an inland sea of brackish water, like the Baltic, existed in the North of Europe, considerable fluctuations in the position of land and sea have taken place; a conclusion to which I shall revert in the sequel.

The elevated position of the marine shells around Södertelje prepares us to expect similar deposits scattered far and wide over the valleys bordering the various branches of Lake Maeler. Accordingly, in examining the country about forty-five miles northwest from Södertelje, between the towns Torshälla and Arboga, I was fortunate enough to meet with abundance of *Tellina Baltica* (see the variety represented in Plate II. figs. 3, 4.) in an unctuous clay, of a deep blue colour when wet, which filled the bottom of a valley near Lake Maeler, in a district of gneiss covered with huge erratic blocks. This locality, which is by far the most distant from the Baltic of all the places where similar beds with marine shells had previously been observed, lies between the village of Smedby and Kongsör, about seventy miles from Stockholm, and more than eighty from the general coast line. The clay is exposed to the depth of fifteen feet, being cut through by a streamlet, which is crossed by a small bridge

on the high road. The deposit is elevated only a few yards above Lake Maeler, and is therefore about the same above the Baltic; but the formation extends to greater heights in this and adjoining low lands, as do associated beds of gravel and sand, in which I could not detect any fossils.

After viewing these geological phenomena, I was well inclined to receive favourably any probable evidence brought forward to prove that the land has been rising in recent times in the neighbourhood of Stockholm; but I must confess that, on close investigation, I was disappointed in finding that several of the proofs relied on by some writers were very equivocal. Among other facts, it has been noticed that the level of Lake Maeler has been lowered in very modern times; and it is clear that the waters of this lake would appear to fall, together with the sea, if there be a general rise of the land, since Lake Maeler joins an arm, or fiord, of the Gulf of Bothnia at Stockholm, the salt and fresh water meeting in the middle of the city. The lake is generally three feet higher than the sea; but the line of separation is not constant, and when the Baltic rises very high, its waters flow for some miles into the lake. In

Fig. 6.



that part of the town called the Riddarholmen, immediately above where the waters of the lake meet the sea, (see Map, fig. 6.,) some of the buildings have of late years become insecure, because the level of Lake Maeler has fallen, so that the piles on which the buildings rest are not constantly under water as of old. The tops of these piles being now every year alternately wet and dry, they are continually rot-

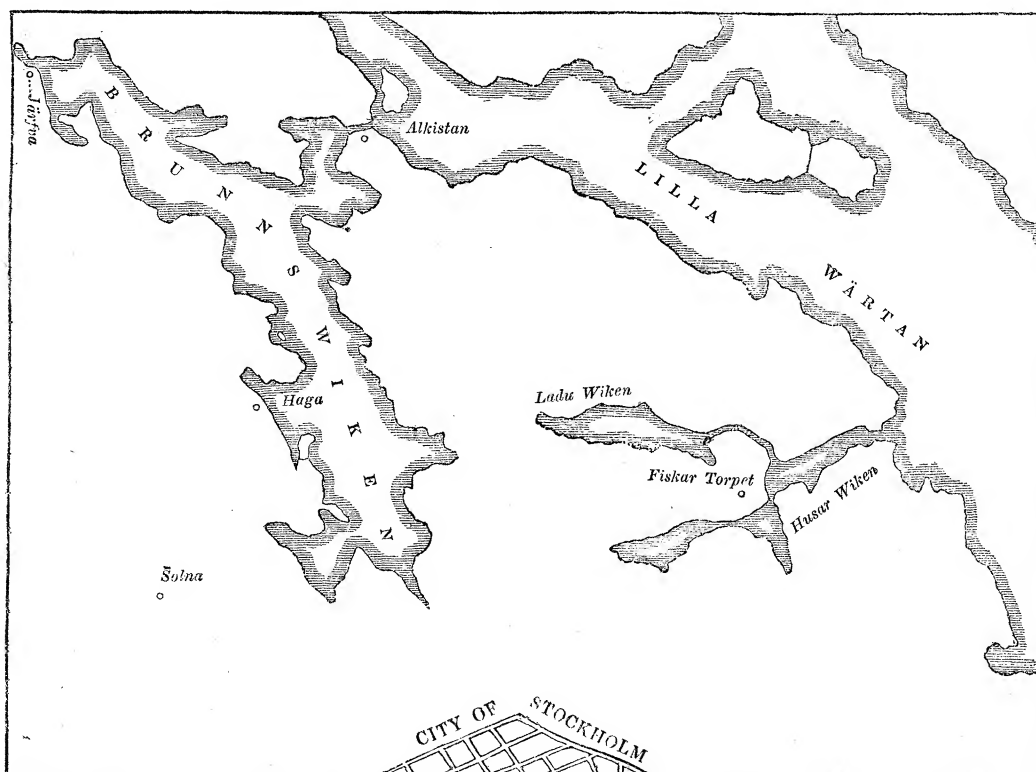
ting away. This fact is unquestionable; and I saw the houses, which, in consequence of this failure of support, are much rent, and out of the perpendicular.

But during the time that this change has occurred, no corresponding fall has been observed in the neighbouring quay, or Skeppsbron, which is filled with brackish water, and which ought to have been equally affected on the supposition of a general rise of the land; and we naturally, therefore, inquire whether some particular circumstances have not of late years given a freer outlet to the waters of Lake Maeler, so as to cause them to sink. Now several Swedish engineers remarked to me, that the decay of the piles had taken place since the removal of the two old bridges in Stockholm, which being supported on a great number of wooden piles, obstructed the free discharge of the lake, the waters of which now pour in a rapid and unbroken current through the large arches of the new bridge; and secondly, they observed that the canal of Södertelje has formed, since the year 1819, an entirely new line of communication, by which the waters of Lake Maeler have of late years flowed out into the sea. Can any one doubt for a moment, that if the old bridge should be restored

and the Telje canal again closed up, the waters of the lake would immediately stand at a higher level*?

There are some marks in the suburbs of Stockholm which serve, I think, to set narrow limits to the extreme amount of elevation which can by possibility have taken place during the last three or four centuries. To one of these, the Fiskartorp of Charles XI., I shall particularly allude, (see Map, fig. 7.,) because an attempt has been made to draw from it the opposite inference of a rapid elevation of the land.

Fig. 7.



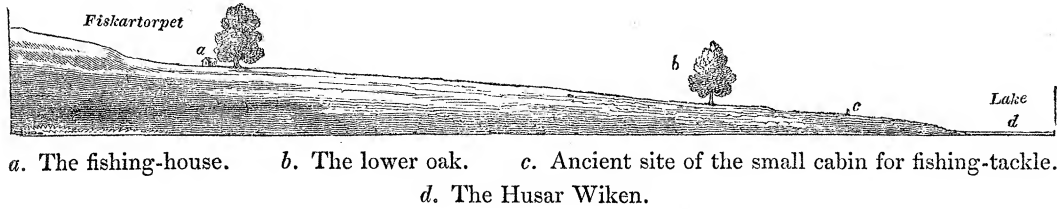
Map of the northern environs of Stockholm, showing the site of the Fiskartorp.

This fishing lodge is situated on a promontory surrounded on three sides by lakes (see Map, fig. 7.). The lodge is 131 yards distant from the nearest water, and twenty-three feet above its level. By the side of it is a large oak, and a second one of considerable age between it and the lake, only forty-six yards from the margin of the water, and having its base only ten feet above the level of the lake, which at the time that I visited it stood at least one foot below its mean height. (See Section, fig. 8.) Mr. STROM, Keeper of the Royal Woods and Forests, assured me that the age of this oak cannot be less than four centuries. There are already some signs of decay at its top, and its diameter at the height of five feet above the ground is four feet four

* Professor JOHNSTON, in his paper in the *Edinburgh New Philosophical Journal*, No. 29, July 1833, has by mistake represented the houses where the piles are giving way as situated on the side of the Skeppsbron instead of the Riddarholmen.

inches. As Mr. STROM is perfectly acquainted with the average rate of growth of the oak in different kinds of soil in this country, and has cut down some in the neigh-

Fig. 8.



bouring grounds which could be shown by their rings of annual increase to be more than six hundred years old, I consider his opinion as worthy of full confidence. This gentleman showed me an ancient plan in which the Fiskartorp and both the oaks were laid down; as also a small cabin, which, in the time of CHARLES XI., who died in 1697, was placed between the lower oak and the lake. It was not a boat-house, but had been merely used for preserving the oars and fishing-tackle. Being in a state of great decay in 1824, it was removed by Mr. STROM. Now it is improbable from what is known of the habits of the oak in this country, that the lower oak grew close to the water's edge originally; and if its base be now only eight feet above the mean level of the lake, it is clear that the rise in each century must have been very slight, although it may undoubtedly have amounted to ten inches in a hundred years, which would accord with the estimate of the best-informed scientific men in Sweden, in regard to the gradual rate of the rise of land at Stockholm. Professor JOHNSTON appears to have confounded the cabin, which has been removed, with the Fiskartorp, which is still standing, the latter having been frequently repaired, as a memorial of CHARLES XI.; for Mr. JOHNSTON states, that "the fishing-hut formerly stood close by the deep water, though no longer near any spot where the favourite amusement of the monarch can be enjoyed*."

Even the lower cabin did not stand near deep water so lately as a century and a half ago, but appears by the ancient plans to have been nearly as remote as now from the shallow Husar Wiken. I fully agree, however, with Professor JOHNSTON, that it appears clear from ancient documents and tradition, that the three lakes Husar, Ladu, and Uggel, which together formed, in the time of CHARLES XI., what was called the Gulf of Fiskartorp, have since grown much shallower, and have been in part converted into land; a change which may perhaps have been due, in part at least, to a slight general upheaving of the whole country. But although I do not dissent from Mr. JOHNSTON's general proposition, I ought to mention here that I consider another of his proofs derived from the neighbourhood of Stockholm as altogether untenable. Speaking of the Bruns Wiken, a beautiful lake in the northern suburbs of the city which skirts the woods and pleasure-grounds of the palace of Haga, (see Map, fig. 7.,)

* Edinburgh Philosophical Journal, No. 29, p. 39.

he says, "the position of this lake shows that it has formerly communicated with the sea, though now it is considerably above it and entirely inland. As the sea retired, this sheet of water would also have been drained off, had it not been dammed up at the only outlet (at Alkistan) to preserve the beauty of the promenade, one of the finest in the neighbourhood of the city. At present it is dammed up to the height of four or five feet, and the character of all the land around shows that in ancient times it has been very much higher and more extensive."

Now a reader would infer from this description, that but for an artificial dam this lake would have been laid dry; but the fact is that it fills a deep hollow in the granitic rocks of this district; and the only effect of the small dam is that the mean height of the water is somewhat more uniform throughout the year. The outlet alluded to is at Alkistan (see Map, fig. 7.), where a slight wooden dam has been erected, so small, that every year in the spring the water flows over it; so that the annual extreme height of the water is still the same as it would be if the dam were removed. When I visited the spot in June, the water was two feet lower than the top of the dam, and scarcely more than a foot above the bottom. The tract of land which separates the lake from the sea is about a hundred paces broad, and is composed of granite, over which the stream flows which issues from the lake.

I shall now pass to the country around Upsala, about forty miles north-north-west of that around Stockholm last described (see general Map, Plate I.). In its geological structure it resembles that of Stockholm, the fundamental rocks being here also gneiss and granite, partially covered with newer deposits and with erratic blocks; but near Upsala there is a much larger quantity of clay in the overlying formation. A section of this clay is well seen at Ulfva on the banks of Fyriså, a spot which I visited with Mr. MARKLIN of Upsala. The thickness of clay here exposed in a vertical section is between thirty and forty feet, and the river is probably as much more above the level of the sea. This stiff blue clay reminded me much of the Subapennine clay of Italy. In some parts it contains no shells; but in others the *Tellina Baltica* entire, with both its valves and the epidermis, is very abundant. It is precisely the same variety of this shell as I found before near Torshälla (see p. 10, and Plate II. figs. 3, 4.). The *Mytilus edulis* also occurs, often much flattened, and occasionally covered with the small white flustra now so commonly attached to it in the Baltic. In some of the associated strata there is much vegetable matter, exactly resembling sea-weed. I could find none of the littoral shells which I before mentioned as associated with the *Mytilus* and *Tellina* near Stockholm.

One of those ridges of sand and gravel which I have before described as being frequent in Sweden, passes through the suburbs of Upsala, running in the usual direction nearly north and south. Its summit, according to the barometrical measurement of Professor WAHLENBERG, rises more than a hundred feet above the river which flows at its base. Its structure is laid open in large pits, one of them about seventy feet deep; and these sections show that the mass consists for the most part of a con-

tinued series of thin layers of sand, loam, and gravel, in part horizontal, but in some places, and for a limited space, inclined at an angle of more than fifty degrees, with numerous small vertical rents occasionally traversing the beds. Whether these have been occasioned by subterranean movements, or during the drying and settling of the mass when it was first raised above the waters, is a point on which I can offer no conjecture. The inclination of the strata, resembling that in gravel-beds, I attribute chiefly to original inequalities in the mode of its deposition. Here, as in other places, I could find no fossils in the beds of pure sand and gravel, nor did I meet with any in the blue clay which seems to crop out from beneath the sand at the bottom of the hill. But fortunately, near the castle at Upsala a thin bed of violet-coloured marl, full of shells, has been cut through at the bottom of a gravel-pit near the top of the ridge. This marl, which forms a horizontal layer only three inches thick, is within about twelve feet of the summit of the ridge, and about eighty above the sea. It contains the *Mytilus edulis*, *Cardium edule*, *Tellina Baltica*, *Littorina littorea*, *Paludina ulva*? Both above and below this marl are strata of gravel, and some of the overlying beds contain round boulders a foot or more in diameter.

This is the only place in Sweden where I met with any fossils in the midst of one of the sand-oasars, or ridges of sand and gravel. The fact of finding the recent shells of the Baltic in such a position appears to me of the highest interest, especially because on the summit of this, as of other ridges, I found large erratic blocks resting immediately on the uppermost layers of gravel or fine sand. In that part of the ridge south of the town called Pålacksbacken, these blocks are abundant, and are on the very summit, appearing to be all superficial, for I could find none *in situ* in the deep gravel-pits which intersect the ridge. I examined these blocks in company with Professor WAHLENBERG, and found them to consist of angular masses of gneiss and granite, the larger ones rarely exceeding nine feet in length; but we measured one which was no less than sixteen feet long, thirteen high, and eight broad. It follows, therefore, that by whatever cause these enormous fragments of granite rocks have been conveyed to their present sites, some of them at least have been transported thither since the Baltic was separated from the ocean and inhabited by the existing species of *Testacea*.

I may observe also, that the occurrence of layers of marl containing littoral shells, as above described, in the midst of a stratified ridge of sand and gravel, is opposed to the theory of those geologists who refer the formation of such ridges to a violent flood or debacle rushing from the north. The perfect preservation of the shells at Upsala, and the repeated succession of thin alternating layers of gravel, sand, and loam, which are seen almost everywhere, imply a gradual, and at times a very tranquil, deposition of transported matter. If I am asked for a more probable hypothesis in the room of that to which I object, I may state that these ridges appear to me to be ancient banks of sand and shingle, which have been thrown down at the bottom of the Gulf of Bothnia, in lines parallel to the ancient coast during the

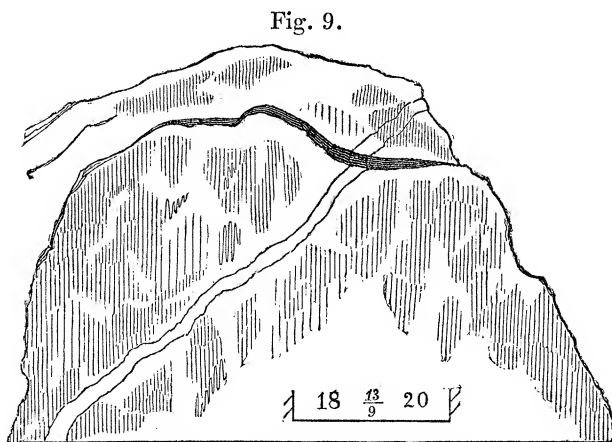
successive rise of the land; or in other words, during the gradual conversion of part of the gulf into land. I conceive that they may have been formed in those tracts where a marine current, flowing as now, during the spring when the ice and snow melt, from north to south, came in contact with flooded rivers rushing from the continent, or from the west, charged with gravel, sand, and mud. According to this view, these large Swedish ridges may be compared to smaller banks known to have been formed within the last five or six centuries on the eastern coast of England, at points where a prevailing marine current from the north meets rivers descending from the interior, or from the east. In such situations the river, instead of entering the sea in a straight line, is deflected at a right angle, and runs from north to south between the land and the new-formed sand-bank. The deep narrow breaches which occasionally occur in many of these ridges in Sweden, precisely resemble those which a flooded river or an inundation from the sea sometimes makes through our smaller banks above alluded to. If this explanation be admitted, I conceive that the steep escarpments often presented on both sides of the oasar or ridges of sand, may be almost entirely due to their original form, and not to subsequent denudation. As to the manner in which the erratic blocks have been lodged on the highest parts of these sand-banks, I fully adopt the opinion of those who believe them to have been carried by ice, respecting the agency of which I shall have more to say in another place.

The low meadows near the town of Upsala are not many feet above the level of Lake Maeler, the most northern arm of which reaches near to that place, which is distant about fifty miles from Södertelje, before alluded to, at the south-eastern extremity of the same lake. If the opinion, therefore, of the rise of the land be well founded, the whole of Lake Maeler, and the low lands adjoining, must have been covered with salt water at no very remote period in history. Professor WAHLENBERG pointed out to me a meadow to the south of Upsala in which the *Glaux maritima* and the *Triglochin maritimus* now flourish, plants which inhabit salt marshes bordering the sea. These same species have, it is true, been found in the interior of Germany and France near saline springs; but in the country of Upsala there are no salt springs; and this botanical phenomenon seems to confirm the opinion that the salt waters have only receded in very modern times from these lands, and that the rains have not yet had time to dissolve and wash away all the salt which may have been originally precipitated when this tract was laid dry.

OREGRUND.

The next region which I examined was the coast near Oregrund, a port about forty miles north-east of Upsala. During the survey of 1820, before alluded to, a mark was made near this place on the rocky cliffs of Gräsö, a long narrow island which lies opposite to Oregrund. On my visit to this island I was accompanied by Lieut. OLOF FLUMEN, a gentleman of the pilotage establishment, who cut the mark in 1820. It is much to be regretted that neither he nor any other observer, as far as I could learn,

had visited these spots since the marks were made. No place could have been better chosen for the purpose: the letters and lines, which are still as fresh as if newly made, have been cut upon the vertical face of a cliff of gneiss, which is free from lichens, and which plunges to the depth of about three fathoms perpendicularly beneath the water. I subjoin a sketch (fig. 9.) which I made of the rock and mark as they appeared on the 1st of July 1834. A vein of granite, composed of felspar and quartz, traverses the gneiss in an oblique direction above the mark. The rock is stated by BRUNCRONA to be in latitude $60^{\circ} 18' N$. It is situated at the south of Strandtorpet and north of Käringsundet. The length of the horizontal line is twenty inches and a half; the figures express that the mark was cut on the 13th day of the ninth month (September) in the year 1820, and the runic letters at the beginning and end of the line are the initials of OLOF FLUMEN.



Mark at Gräsö near Oregrund.

At the above date the horizontal line was exactly at the level of the sea on a calm day, when the water was supposed to be at its standard level. When I visited the place on the 1st of July 1834, the line was five inches and a half above the surface of the water; and Lieutenant FLUMEN and the seamen thought that a slight wind which was then blowing from the north-north-west, directly down the sound between Oregrund and Gräsö, caused the water to be an inch or two higher than it would have been had the sea been as perfectly calm as on the day preceding my visit. I found the pilots, both here and at other places on this coast, to be of opinion, that notwithstanding the fluctuations of level caused by the wind, a person well accustomed to this sea can decide whether, on a particular day, the water is an inch or two above or below its standard level. There had been several calm days without wind before I arrived at Oregrund, and I was assured that the sea was in a state of rest similar to that of the day which had been chosen fourteen years before for making the mark. Before we came to the spot, both Lieutenant FLUMEN and the boatmen expressed their persuasion that I should find the sea below the mark, because they declared that either the waters of the gulf were always sinking, or the land on this coast was gradually rising. To confirm this opinion the sailors pointed out several rocks which they well remembered to have been barely covered with water in their younger days, or about forty years ago, but which now rise between one and two feet above the water. Among others they took me to a small insulated rock in the sea, opposite Domaskärsund, which they recollected to have once been nearly two feet lower, at which time the neighbouring channel, which I saw nearly dry, had allowed a loaded

boat to pass. So strong is the conviction of the fishermen here, and of the seafaring inhabitants generally, that a gradual change of level, to the amount of three feet or more in a century, is taking place, that they seem to feel no interest whatever in the confirmation of the fact afforded by artificial marks, for they observed to me that they can point out innumerable natural marks in support of the change; and they mentioned this as if it rendered any additional evidence quite superfluous.

The sea deepens rapidly near the coast at Oregrund, and there is twenty-eight fathoms water in the bay. Along the shore is a broad band of bare gneiss traversed by granite veins, which ramify in every direction, and consist chiefly of felspar in large crystals. In many places this sloping band of bare rock, having a smooth surface, extends up for a hundred paces from the sea, covered only with a scanty coating of lichens. The gneiss, where it approaches within eighteen paces of the sea, is so smooth and polished that it is difficult to walk upon it. The surface swells into those rounded flattened forms which are so common in the forests in the interior of Sweden, where grass is frequently unable to establish itself on so hard a foundation. Not even lichens can grow in some parts where veins and beds of quartz appear; but trees take root in the clefts of the granite and gneiss, rising amidst vast erratic blocks, resembling those which, in equal numbers and of equal dimensions, crowd the greater part of the shores and islands of the Bothnian gulf.

From Oregrund I went on to Gefle, about forty miles to the north-west. In a low part of the intervening country, near the village of Skjerplinge, I came to a large tract of stiff blue clay, like that near Upsala, covered with sand six or eight feet deep. In the clay I found the *Mytilus edulis* and the *Tellina Baltica*. I was informed that marine shells are met with abundantly at a much higher level in a hill of sand near Skjerplinge, where also, according to tradition, a large iron ring, such as ships are attached to, was formerly found fixed in the soil.

My attention was repeatedly called to low pastures from one to three miles inland, where the old inhabitants or their fathers remembered that boats and ships had sailed. The traveller would not have suspected such recent conversions of sea into *terra firma*; but there are few regions where a valley newly gained from the sea may so rapidly assume an air of considerable antiquity. Every small island and rock off this coast is covered with wood, and it only requires that the intervening channels and fiords should dry up and become overspread with green turf for the country to wear at once an inland aspect, with open glades and plains surrounded by well-wooded heights.

Among other stories of wrecked vessels found in the interior, I was told at Gefle that a vessel and an anchor had been found in a hill of sand and gravel at Uggleby, sixteen miles from the sea, in the parish of that name. Colonel HÄLLSTROM tells me that similar traditions are common in Finland, and that a wreck is said to have been found there at Laihela, two miles from the sea.

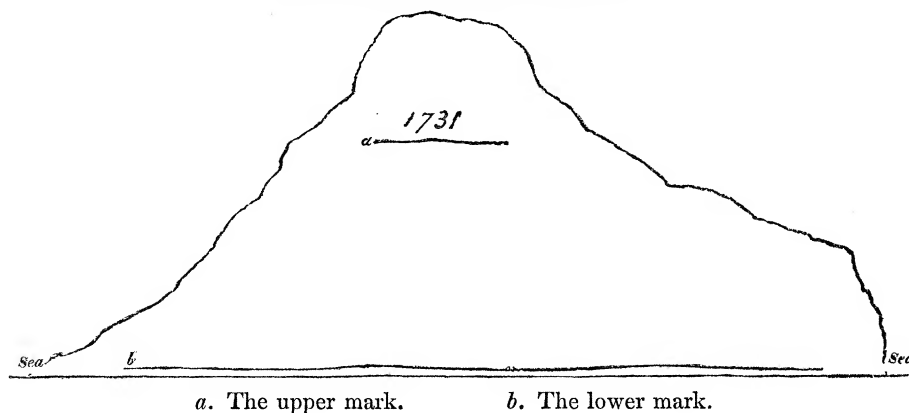
On both sides of the river at Gefle I found land gained from the sea, within the

memory of persons now living ; and its gradual extension here, and in other places to the north and south, is attributed by the natives to a slow but constant change in the relative level of land and sea. In this place the deposition of fluvial sediment must cooperate with other causes ; but the shallowing of the water and its conversion into land are too universal to be explained by sedimentary accumulations alone. Preparations are making to remove the harbour farther from the town, in consequence, as I was assured, of the continued fall of the water rendering it every year more difficult for ships to reach the ancient wharfs.

I visited two marks near Gefle, one of them cut in 1731 in the island of Löfgrund, twelve miles north-east of that port, and another made in 1820, about six miles farther north. The first of these marks (that of Löfgrund*) was carved by one RUDBERG in 1731, on a fixed rock of mica-schist, in the middle of a small sheltered bay on the east side of the island. The mica-schist is very hard and full of garnets, the highest part of the rock being only four feet above the water, and its length and breadth about fourteen feet. There is a depth of water of about seven feet and a half on the side where the mark is made. The annexed sketch (fig. 10.) will give some idea of the outline of that side of the rock and of the mark.

Fig. 10.

Rock in the Harbour of Löfgrund.



The horizontal line, which is somewhat irregularly cut, is known to have been originally made at the mean water-level. When I measured it on the 3rd of July 1834, this line was two feet six inches and a half above the mean level of the water ; but as the wind was blowing from the east-north-east, the chief pilot of Gefle, who accompanied me, declared that I ought to add at least four inches more in order to express the full difference of the ancient as compared to the present level of the sea. It will appear that I had afterwards good reason to believe that this estimate was not exaggerated. Even when this allowance is made, the fall, in the space of somewhat more than a century, is not quite equal to three feet. There is a lower horizontal mark two feet five inches long, irregular and without any date, which, when I ex-

* Sometimes called Löfgrundet, the final *et* being the definite article in Swedish.

amined it, was washed and almost covered by the ripple on the surface of the water. It is not enumerated by BRUNCRONA as among those which were cut in 1820; but my boatmen and the fishermen on the island said it was cut in 1820. Although occasionally covered by the small waves, it was one inch and a half above the mean level of the water, and would probably have been four inches or more above it on a calm day.

It has been observed that lichens grow nearly to the water's edge on the rocks skirting the Gulf of Bothnia, and certainly the lower border of this line of vegetation often appears very distinct when viewed at a short distance; the rock below, where it is alternately wet and dry, remaining of its natural colour, which is usually very much contrasted with that of the surface, where it is coated with lichens. Now it has been proposed to measure and note the distance of this line of vegetation above the sea, and then to determine, after a certain lapse of years, the rate of elevation of the land, by observing how much lower the lichens have descended. With a view of furnishing data to future observers for such comparisons, I endeavoured, at Löfgrundet and other places, to ascertain the height of this line of vegetation, but without success, for it always appeared to me undefinable. Not only is it very uneven, but sometimes, after passing over a space of bare rock, we come down again to some straggling lichens growing luxuriantly nearly to the water's edge.

VON BUCH mentions in his Travels* that he found a large quantity of fine-grained red sandstone, used as a building-stone, at Gefle, containing small nodules of asphaltum. He was told that these stones were found nowhere *in situ*, but were thrown up by the sea upon the skär, or that line of rocks and islands which bounds the coast off Gefle. I found the shore of the isle of Löfgrund strewn over with these schistose red-sandstone blocks. They have the form of large flat slabs, with angular edges, as if they had been just taken from a quarry. They were exposed to a hot sun, and the black pitchy matter was oozing out abundantly from numerous pores. The planes of stratification presented those undulations called ripple-marks. On my inquiring from whence they came, I was assured by the fishermen that a fresh supply of such masses was brought to the coast from time to time by the sea. I remarked that their size was such that the waves could not have power to move them, that there were no rocks like them in the neighbourhood, and that they were not rounded by attrition as if rolled at the bottom of the sea. One of the fishermen replied that the ice might have brought them, and he undertook to show me much larger blocks which had been stranded recently on different parts of the skär. I accordingly went to a small island called Hvitgrund in order to see proofs of this fact, and there I observed blocks of red granite, five or six feet in diameter, perfectly free from lichens, amidst other blocks of various sizes which were coloured grey, white, and black, by a coating of these plants. The sailors named other spots where I might see much larger blocks, perfectly bare, or only beginning to be covered, amidst

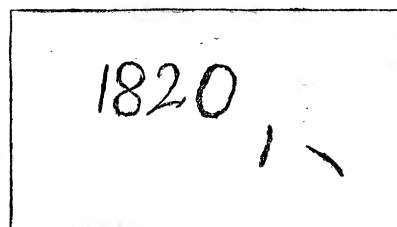
* Vol. ii. chap. v. French edition, p. 303.

thousands which, having probably lain for a great many years at the same height above the mean level of the sea, had entirely changed their colour. They declared that they well knew the exact date of the arrival of some of these blocks, which they observed would in time become as well coloured (or as thickly clad with lichens) as those older ones among which they had been thrown. On my demanding whether any of my informants had seen great stones floated by ice, they admitted that they had not; but the chief pilot stated that the drift ice on this coast is often *packed* so as to be eighteen feet thick, different sheets from five to six feet in thickness being driven one over the other; and when this happens, fragments of rocks might be frozen in and floated off on a rise of the water or a change of wind. The more usual mode, however, of explaining the manner in which ice operates is somewhat different. When the sea freezes in winter to the depth of about five or six feet, detached masses of rock lying on shoals are necessarily frozen in. Afterwards, when the water rises on the approach of summer, the ice, being buoyed up, lifts with it these stones, and they may then be transported by floating ice-islands to a great distance.

The next mark which I examined was that of St. Olof's Stone in Edskö (or Edsjo) Sund*, in the parish of Hille. There was no one at Gefle who was present in 1820 when the mark was cut, and unfortunately it is imperfectly and even incorrectly described in BRUNCRONA'S Report. St. Olof's Stone is an immense erratic block, about thirty-six feet high above the water, forty long, and thirty broad, with precipitous and in some places overhanging sides. It consists of micaceous schist with garnets. It is situated in lat. $60^{\circ} 52' N$. The mark is cut on the precipitous south-east side, at the base of which there is about a fathom's depth of water.

BRUNCRONA, in his Report, states that the mark consists of a horizontal line, upon which the date of the year 1820 is carved. Directions were probably given by him to this effect, but they have only been in part executed, for there is neither a horizontal nor vertical mark, but only two irregular lines to the right of the figures, as shown in the annexed sketch. It is also stated in the Report, that the water stood 1.92 foot under the lowest edge or base of the ciphers. Now unfortunately, the base of the letters do not form a perfectly horizontal line, the bottom of the last cipher being three quarters of an inch below the bottom of the figure 8. On the evening of July 3rd, I found the water-level to be exactly two feet below the base of the cipher, or the 0. The wind was blowing from the east-south-east, so that the water in the Sound, according to the pilot's opinion, was four or five inches above its level of equilibrium.

Fig. 11.



As this was the third time I had been told that the sea was several inches above its standard height, I determined to pass the night in Edskö, in hopes that the wind might fall, and that I might have an opportunity of repeating my observation during

* Colonel BRUNCRONA has called this Assiasund, but it is not known by this name at Gefle.

a perfect calm. At a very early hour the next morning the wind shifted to the north-north-west, and fell almost entirely, so that when I revisited St. Olof's Stone the surface of the water was perfectly smooth. I then found the level of the sea, as the pilot had expected, $3\frac{1}{2}$ inches lower than on the preceding evening. This circumstance gave me much confidence in the opinion which he had previously expressed, that the water at Löffgrund was three or four inches above its standard level at the time of my observation.

The result, then, of my second visit was, that on a moderately calm day, with a slight wind blowing north-north-west, I found the level of the water, on July 4, 1834, two feet three inches and a half below the bottom of the 0, at the end of the figures 1820, or 3.58 inches lower than the water in the year 1820, supposing the measurement to have been then taken from the base of the last cipher. If it was taken from the base of the figure 8, then the difference between the water-level at the two periods compared would be three quarters of an inch greater.

It is much to be regretted that in the printed account of the cutting of this and other marks in the year 1820—21, no exact mention is made of the state of the sea and direction of the wind. I was merely assured generally that calm days were chosen, and circumstances avoided which are known to cause the Gulf to deviate from its standard level. This precaution I know to have been carefully attended to at Oregrund.

Mr. VON HOFF, in his important work entitled "The History of Natural Changes on the Earth's Surface proved by Tradition," has objected to the marks cut on the rocks of this coast that they were made on loose blocks, which may have been heaved up from their position by the sea and ice*. But the greater number of the marks have been set on fixed rocks; and even where this is not the case, the proof derived from such enormous masses as St. Olof's Stone is quite unexceptionable. I ought, however, to add, that Mr. VON HOFF has, in the third volume of his work just published, withdrawn his opposition to the validity of the evidence in favour of the rise of land now going on in the Baltic†.

Before I pass from Gefle to another part of Sweden, I may state that Colonel HÄLLSTROM, to whom we are indebted for an interesting article on the marks made to determine the rate of change of level in the Bothnian gulf‡, informed me that the inhabitants of the opposite coast of Finland are as fully persuaded as those between Gefle and Torneo that either the waters are falling in their country or the land rising. The same gentleman observed, that notwithstanding the fluctuations of level in the Baltic at certain seasons, he never happened to examine any of the ancient marks, either on the Swedish or Finland side of the gulf, without finding the water below the marks. He also gave me some marl of a violet colour, which he had lately brought from Nädendal, near Åbo, in Finland, found at the height of sixty feet above the level

* Geschichte der Veränderungen, Part I. p. 425.

† Ibid. vol. iii. p. 316.

‡ Kongl. Vetenskaps-Academiens Handlingar, Stockholm, 1823, p. 30.

of the sea near the coast. It is composed principally, like that before mentioned near Stockholm and Upsala, of the decomposition of the *Mytilus edulis*, but also contains perfect specimens of the *Tellina Baltica*, *Littorina littorea*, *L. rudis*, and *Paludina ulva*.

The castle of Åbo on the Finland coast has been cited by several writers* as proving that the ground on which it stands has not been elevated, that building being many centuries old and yet close to the water's edge. But Colonel HÄLLSTROM assured me that the base of the walls is ten feet above the water; so that the castle may be four centuries old, and yet there may have been a gradual rise of the land at that point to the amount of more than two feet in a century.

Not being able to visit Sundsvall, I applied by letter to Mr. JAMES DICKSON, resident at that port, who at my request put a series of questions, which I had drawn up, to the most experienced pilots and fishermen on their return in November last from their fishing-stations in the Gulf of Bothnia. In their answers they stated:

1st, That they could not conceive the possibility of the land rising, but were of opinion that the sea had been sinking gradually in the Gulf of Bothnia, the fall during the last thirty years amounting to two feet, or thereabouts:

2ndly, They had never seen any of the marks cut in the rocks in 1820; but from other appearances they inferred that the fall of the waters in the last fourteen years, in the neighbourhood both of Sundsvall and Hernösand, was from six to eight inches:

3rdly, They had found it necessary in their own time, in consequence of the retreating and shallowing of the waters, to remove their stations or fishing-posts nearer to the sea:

4thly, They could point out examples of large blocks of rock which had been moved and even conveyed from one place to another by ice, both on the shores of the islands of the Gulf of Bothnia and on those of the main land.

I shall now pass over from the shores of the Baltic to the opposite coast of Sweden between Uddevalla and Gothenburg, a district from 250 to 300 miles south-west of that before described, and about three degrees of latitude farther south. The deposits containing recent shells at Uddevalla, raised in some spots to the height of more than two hundred English feet above the sea, have long been celebrated; as also the discovery, made by M. ALEXANDRE BRONGNIART, of barnacles attached to elevated rocks of gneiss on the spots where they must have grown. I was desirous of seeing this phenomenon, as it appeared to me that it might throw some light on the time which has elapsed since the shelly beds were raised from the sea; for if the *Balani* had been exposed in the open air ever since the emergence of the rocks to which they were fixed, it could hardly be supposed that the time had been indefinitely great, since in that case the shells must have been decomposed. The fact recorded by M. BRONGNIART was, I believe, observed at Capellbacken, immediately south of Uddevalla, where there is a narrow valley in the gneiss, the bottom of which is filled up with a great deposit of shells, sand, and clay, which rise, according to HISINGER, at their greatest eleva-

* See VON HOFF, Part I. p. 438.

tion 206 English feet above the sea*. I searched in vain for the *Balani* round the boundary of gneiss at its contact with the beds of shells, as also on some insulated rocks of gneiss which had been newly laid bare by the workmen, the shelly matter being removed as materials for the repair of the roads. I presume, however, that it was in just such a situation as that last mentioned that M. BRONGNIART found the adhering barnacles; for under similar circumstances I afterwards found them in another place, called Kured, about two miles north of Uddevalla†. Here a mass of white shells has been laid open to the depth of forty feet, in a quarry resembling singularly, when seen at a distance, one of our chalk-pits. Although now two miles from the nearest sea, and a hundred feet or more above it, they evidently fill what has once been a narrow channel, or fiord, bounded by rocks of gneiss. The deposit now forms a flat inland meadow, the fertility of which is contrasted with the steep and barren rocks which rise above it on all sides. It consists here almost exclusively of broken and entire shells, which lie in thin strata. They have been used largely both for making lime and for road materials; and the removal of part of them has exposed a ledge and precipice of gneiss, which they must previously have covered to some depth. Adhering to the face of this precipice, I found the circular supports of many large *Balani*. Some of these supports (see Plate II. figs. 38, 39.) were three quarters of an inch in diameter; and being white, they spotted the rock, so as to present at a distance exactly the appearance of lichens. I also found in horizontal clefts between the rocks pendent barnacles, fixed to the roof so firmly that I was able to break off pieces of the hard gneiss on which the shells still remained attached. In some places small zoophytes (*Cellepora?* LAM.) were adhering to the rock or to the *Balani*; and I also found some of the *Cellepores* with the support of the *Balani* partially covering them. These corals and adhering shells, therefore, must have grown upon the gneiss before the accumulation of drift shells had filled up this valley, once a submarine hollow. I had always imagined that the shelly formations near Uddevalla resembled ancient beaches of the ocean which had been upraised, but they are in fact stratified formations of sand, clay, and gravel, and in several places almost entirely of shells, which have filled up at some former period the deep bays and fiords of a sea like that now bounding this coast. The quantity and variety of the shells at Capellbacken, Kured, and Bräcke reminded me of the deposits of Grignon and Damerie in the Paris basin; but it is curious to reflect, that although the shells are almost equally well preserved in both these regions, they are specifically so distinct, that in the one it is scarcely possible to find a recent species, while in the other nearly all, perhaps every one of the species, belong to the German Ocean. The list of the shells which I collected here in one day will be found at the end of this paper; and although it will probably give but an imperfect idea of the

* Anteckningar, &c., v. p. 81.

† M. BRONGNIART says that he found the barnacles "un peu au dessus de l'amas coquillier," (Tableau des Terr. p. 89); but this may refer to what then remained of the shelly mass.

entire number which might be found, it will serve to show that a considerable variety exists here.

The difference of this assemblage of shells from the fossils which I had before examined near the shores of the Baltic was very striking. A considerable proportion of the whole mass, especially at Kured, was made up of the loose valves of a large barnacle (*Balanus tulipa*,—see Appendix), to which I imagine the large supports belong which covered the surface of the gneiss at Kured. These supports exhibit a number of concentric rings of growth, often very regular (see Plate II. figs. 38, 39.). When the animal died, the shell seems to have been easily broken off from the rock, and we must suppose successive crops of them to have been supplied for ages before such enormous heaps of stratified shells were amassed. The *Balanus sulcatus* is also very common, of a large size, remaining entire, with its support. Some of these I saw fixed to the rock as before mentioned; but generally they are found adhering to valves of the *Mytilus edulis*, or large valves of the *Pecten islandicus*, of which last the colour is preserved. Not one of these *Balani*, nor any species of that genus, inhabits the Baltic. The shell next perhaps in abundance to the large *Balanus* is *Saxicava rugosa*, of which the valves are often of extraordinary thickness, and must have belonged to very aged individuals. The two valves are sometimes united; but I never found them lodged in any cavity either of a rock or zoophyte: perhaps they may have inhabited the roots of large sea-weeds. (See remarks on this shell in the Appendix.) The thick shells of *Mya truncata* are also in great quantity; and the *Mytilus edulis* four or five times larger than in the Baltic, and retaining much of its colour. A *Fusus* also (*Murex Rumphius*, MONT.) occurs in profusion.

I found at Uddevalla many bivalve shells, in which small holes had been drilled by predaceous Trachelipodes, whereas among the fossils near Stockholm and Upsala I could never meet with a single bivalve so perforated; and there are, I believe, no zoophagous *Mollusca* now living in the Baltic.

From Uddevalla I went to the small island of Gulholmen (see Map), in the parish of Morlanda, part of the coast not far from Uddevalla, where CELSIUS declared, at the beginning of the last century, that the sea was sinking. On my way I crossed Orust, an island about fourteen miles in diameter, consisting chiefly of micaceous schist, forming low hills a few hundred feet high, resting upon which, at different elevations, are beds of sand, gravel, and clay, sometimes entirely destitute of shells, but often inclosing many recent shells, for the most part the same species as at Uddevalla, but with the addition of the *Ostrea edulis* and *Cerithium reticulatum*. I met with some of these fossils between Hogan and Morlanda in a blue clay, which seemed to lie at a higher elevation than any of the shells near Uddevalla. The features of the scenery in the interior of Orust are precisely such as we might suppose the present coast to exhibit if it should be lifted up with its small islands, rocks, and friths, and if the intervening level flats, where sand, mud, and shells are known to be now accumulating, should be laid dry. An account was given me of the finding of an anchor near Morlanda,

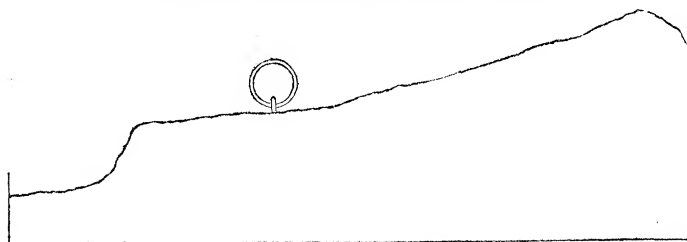
in a valley, the lower part of which had gained considerably in extent, within the memory of persons now living, by the retreat of the waters. In descending to Ellelös on the eastern coast, opposite the island of Gulholmen, I observed shelly deposits about fifteen feet above the level of the sea, in which were many specimens of the *Ostrea edulis*, *Saxicava rugosa*, *Cerithium reticulatum*, and other shells, some of which I had seen at Uddevalla, and others cast up on the shores in Orust.

In regard to the island of Gulholmen, CELSIUS tells us that in his time forty pilots, none of whom were under sixty years of age, having been assembled there, had unanimously declared to one Mr. KALM that there was only fifteen feet depth of water in places where in their youth there had been eighteen feet. He also mentions that one of the pilots pointed out a small rock near Gulholmen, then rising two feet above the water, which, when he was a child, was not visible*.

The present inhabitants, as far as I conversed with them, are entirely ignorant of any such statements having been recorded a century ago; but on my demanding whether the water stood now at the same level as in their younger days, they unanimously declared that it did not. Mr. BRUNCRONA, in his memoir before cited, mentions that on an insulated rock called Gulleskär, near the harbour of Gulholmen, there was an iron ring to which ships were moored, and that this ring, when measured in 1820, was eight feet above the level of the water. Unfortunately, no particulars are given; and as both the chief pilot of 1820 and another who assisted him in the measurement were dead at the time of my visit, I could not ascertain with certainty from what point of the ring they had begun their measurement, nor the means they had taken to secure accuracy. Having obtained the assistance of JOHAN WUNSCH, now chief pilot, I found the point where the ring is fixed into the rock to be only seven feet five inches above the level of the sea, which was then declared to be at its usual level, a very slight wind only blowing from the north-north-west, and there being never any tides in the sea here. The iron ring, which has remained for more than half a century in its present place, is fifteen inches in diameter, and the top of it stands more than eighteen inches above the level of the rock when it is erect, in which position I found it, thus (see fig. 12), having been so placed for the sake

Fig. 12.

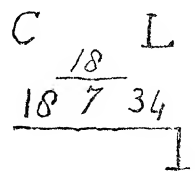
Summit of the Gulleskär, with the Ring.



* CELSIUS, Observations on the Diminution of the Waters of the Baltic and German Ocean.—Trans. Roy. Acad. of Sweden.

of drying the fresh paint, with which it had been just covered ; but the islanders suppose the measure to have been taken from the bottom, or point where the staple enters the rock, which seems most probable. Curiosity led a great many of the inhabitants to accompany me ; and when I declared that the height of the ring was seven inches less above the water than that recorded by BRUNCRONA, many of the older men with one accord pronounced this to be impossible, and said that the former observation must have been incorrect, for that the sea must, on the contrary, have fallen since 1820. Some of them affirmed that the pilot who received orders in 1820 to make the measurement was ignorant in what manner to proceed, the place of the ring not being perpendicularly over the water, and he having no instrument for levelling, so as to ascertain that the line which he first carried out from the ring was strictly horizontal. Whether there was any foundation for this charge I cannot pretend to decide ; but I mention it as proving that the islanders believe that there is a change of level going on. It may be useful to those who may make future measurements to state what length of line it required to reach from the iron staple of the ring to the nearest point of the rock to which the sea comes up, this point being now exactly in the direction north-west and by north of the ring. I stretched the rope from one angle to another of the rock, not applying it to the surface of the intervening hollows, and found its length to be fifteen feet five inches and a half. As the Gulleškär, however, is by no means well chosen for the facility of observations, I had a new mark cut on the face of a vertical cliff on the south side of the harbour, about a hundred yards from the post-house. I subjoin a copy of the mark, the lower part of which was cut in my presence, and which the chief pilot promised to see completed. The horizontal line was cut six inches above the water-level, and the vertical line at the right end of it, six inches in length, was terminated at the bottom by a short cross line, which the surface of the water just covered. The vertical depth of water below the mark was four feet two inches and a half. I may suggest, that whenever horizontal lines or any marks are made, like that of St. Olof's Stone before mentioned, *not* at the level of the sea, but at a certain height above it, on a vertical face of rock, there should always be a perpendicular line cut down to the then existing level of the water, to facilitate subsequent observations and prevent mistakes. Marks cut at given heights above the standard level are perhaps the best, as they are not concealed by a temporary rise of the water.

Fig. 13.



Before leaving Gulholmen I visited the Skefverskär, an isolated rock which, according to the testimony of several old people, was always covered, except at very low water, about forty years ago. In their younger days, before the year 1799, when the present church of Gulholmen was built, they went to church at Morlanda, and passed near this rock, the exposure of the summit of which was a well-known sign to them of a particular state of the weather. This rock is now always seen except when the sea is very high. I found the highest point of it to be sixteen inches above the level

of the water ; and its extreme length from east to west, including a detached point at one end, measured fifty-two feet four inches and a half.

From Gulholmen I went to Marstrand, an island about twenty miles to the south, in order to observe another of the marks enumerated by BRUNCRONA. I first recrossed the ferry at Svansund to the main land, and then passed to that of Tjufkil, which leads to Koon. On the shore at Tjufkil I found a bed of oysters and other shells, five or six feet thick, with pebbles intermixed, rising to the height of sixteen feet or more above the water. The oysters, which were in great number, all belonged to the *Ostrea edulis*, which is taken on this coast ; and the other shells were the same as at Uddevalla and Ellelös, with the addition of *Anomia striata*. This shelly deposit has been overwhelmed by a great fall of rock from the steep heights of gneiss behind, some of the fragments which cover the shells being about nine feet square.

Not far from the harbour at Marstrand is an artificial channel, which, in the year 1770, was cut through an isthmus which formerly connected two parts of Koon island. The excavation was made through a mass of clay and sand with shells, similar to that of Tjufkil, already mentioned ; so that there can be no doubt that there must originally have been a natural passage in this place. One Captain CONSTANT, who superintended the digging of the channel in 1770, caused a mark, of which the following is a sketch, to be hewn on the face of a vertical rock of micaceous schist on the shore of Koon, nearly opposite Marstrand.

Fig. 14.
Mark at Koon Island, near Marstrand.



An horizontal line, ten inches long, is seen twenty-one inches below the bottom of the last cipher. This line I found to be just ten inches above the level of the

water. My observation was made on the 19th of July 1834, sixty-four years after the mark was cut. Now my boatmen stated that the horizontal line was originally intended to express the lowest level to which the sea fell at the time of digging the Koon canal ; and this information was confirmed by Mr. O. J. WESTBECK, who resides in the immediate neighbourhood. On my applying to this gentleman to learn whether the water at the time of my observation might be considered as unusually low, he said that as the wind was easterly, the sea was certainly below its mean level, but it had by no means reached its extreme point of depression, for there still was water in the Koon canal, immediately opposite his villa ; whereas, after the prevalence of a strong easterly wind for two days, the sea falls so low that certain parts of this canal are dried up. He suggested, therefore, that by measuring the depth of water in those parts of the canal which dry up, and adding that depth to the ten inches which I had already obtained below the mark only half an hour before, I should ascertain the point of extreme low water as compared to that of 1770. We accordingly found that the water in the places alluded to was fourteen inches deep ; so that the lowest water now is two feet below the maximum of depression sixty-four years ago. Mr. WESTBECK said that he had always heard from his father that the mark, which was cut the year he was born, was intended to express the lowest level of the sea during the digging of the canal in 1770.

I have already stated that there is no tide on the coast here, a circumstance which seems very extraordinary ; but all the pilots and seamen agree in asserting the fact. A strong wind off the shore causes the water to fall two or three feet, and to rise as much if it be in the opposite direction. Notwithstanding these occasional oscillations, the inhabitants pretend to determine whether the sea is two or three inches above or below its standard level. I was shown here, as at other places, rocks which forty or fifty years ago could rarely be seen, but are now permanently above water. I was also told of numerous rocky channels where boats could once pass, but which had now grown too shallow, and of meadows which were yielding from time to time a larger quantity of hay, in consequence of their increased extension on the side towards the sea.

I know not how much further to the south the same signs of a rise of the land have been observed, but it is certain that the narrow frith in which the port of Gothenburg is situated has been gradually filling up, in such a manner as would happen if the same cause of change was cooperating there with the deposition of river-sediment. It is well known that in the sixteenth century the ancient port was placed twenty miles further up, and called Lödese ; and this was afterwards removed further down, and called New Lödese, to distinguish it from what remained of the more ancient harbour. But now the newer of these places is called Gammle Staden, or the old town, and is a mile or more above Gothenburg.

On the banks of the river at Gothenburg I found a deposit of blue clay, filled with a great variety of recent marine shells. Among others, *Lutraria compressa* ; *Macra*

subtruncata, very abundant; *Tellina solidula*; *Donax trunculus*? DILLWYN; *Cyprina Islandica*, *Venus gallina*, *Cardium edule*, *Littorina littorea*, *Turritella terebra*, *Rostellaria pes pelicani*, and *Buccinum reticulatum*. This part of the estuary is now always filled with fresh water, except on rare occasions, and for a short time, when a strong wind drives the sea up the river, and causes the water to rise six feet, in which case it becomes brackish. At different heights above the sea, in the valley of the Götha Elf, between Gothenburg and Trolhättan, marine shells have been found similar to those of Uddevalla.

Some persons who have been long resident in Gothenburg pointed out to me, as a proof that the water was falling there, that the rocks several feet above the highest water-mark were bare and uncoloured, by which they meant that no lichens grew upon them.

A similar remark had been made to me at Tjufkil, Svansund, and other places on this coast. It seems probable that some species of lichen may require a much longer time to establish themselves on newly exposed rocks than others; and I could observe distinctly, near Gothenburg, that some kinds approached nearer the water's edge than others, and that the variety of species became greater and the colour different on ascending to greater heights. It would therefore be an interesting point for a geologist sufficiently skilled in botany to determine whether the extent of the lichens and mosses downwards towards the water on this coast, where the rocks are supposed to be always rising, presents different phenomena from the line of vegetation on other coasts, where the relative level of the land and sea is known to have remained stationary.

On many parts of the eastern coast, above described, the sea freezes in severe winters in the Skär; that is to say, among the rocks and islets which skirt the main land, and where there is almost always still water. As I have before mentioned the accounts which I received of the transporting power of ice in the Gulf of Bothnia, it may be well to state some facts bearing on the same subject which I learnt at Gothenburg. In the harbour of that port there are a great number of strong wooden piles, called dolphins, three or four feet in circumference, the lower parts of which are sunk to a considerable depth in the mud, and firmly fixed in it, so that vessels may be moored to their tops. As these dolphins are annually frozen in, it is found necessary to break the ice round them; but sometimes this has been neglected, and Mr. HARRISON, the English Vice-Consul, informed me, that on such occasions he has known a great number of the piles drawn up together out of the mud six feet perpendicular, a rise of the river having caused the ice to float up to that amount.

Mr. WESTBECK of Marstrand, to whom I have already alluded, mentioned to me, that having been formerly employed in the Swedish Diving Company for thirty years, he had opportunities of witnessing the extraordinary power of ice to lift up from the bottom of the sea and remove to a distance very heavy masses. In two instances the ice collected round sunken vessels which were under his charge, and having frozen

round them, floated them off with their cargo and ballast from shallow into deep water.

I shall now state some general conclusions to which I have been led by the observations above described. It is evident from the position of the fossil shells of recent species on the coast of the Baltic between Gefle and Södertelje, and on the shores of the ocean between Uddevalla and Gothenburg, that the tract of land (see Map, Plate I.) which once separated the two seas in this region was much narrower at a comparatively modern period. Shells like those of Uddevalla have not only been found a few miles due east of that place, but as far inland as Trolhättan in digging the canal there*; and still further in the interior, about fifty miles from the coast at Tusenddalersbacken, and other places near Lake Rogvarpen in Dalsland, on the west side of Lake Wener (see Map, Plate I.). Of these fossils an account will be seen in the works of Mr. HISINGER, to whom we are indebted for a valuable geological map of the whole of the south of Sweden. They are found in Dalsland about as far above the sea as near Uddevalla, or about two hundred feet high; so that when they were deposited, we must suppose the whole of that extensive Lake Wener, the surface of which lies at an inferior level, to have formed part of the ocean. On the other hand, when the marine shells of the environs of Upsala, Stockholm, and Torshälla lived in the Baltic, we must suppose the whole of Lake Maeler to have been a bay of that sea. Now the distance between the nearest points of Lakes Wener and Maeler is only about seventy English miles, whereas there is more than three times that distance between Stockholm and Uddevalla, the nearest points at which the two seas now approach each other in the same direction. It is very desirable that Swedish geologists should pursue this subject still further, and ascertain precisely how far the shells of the two seas can be traced inland in opposite directions.

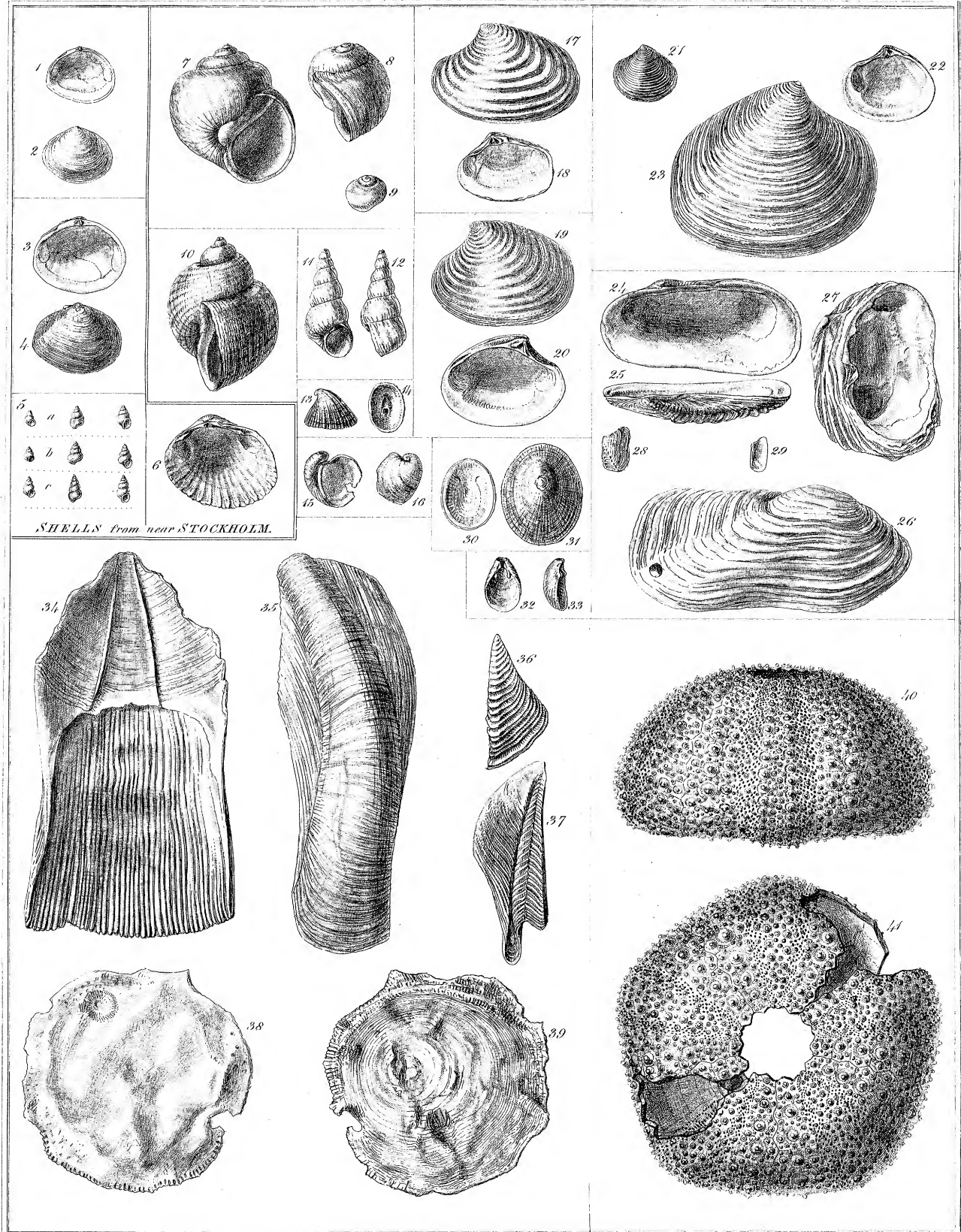
In crossing from Stockholm to Södertelje, Arboga, Orebro, Mariestadt, and Wenersborg to Uddevalla, I passed the summit level of the country, about half-way between the Baltic and the ocean, near Bodarne, where the hills, as VON BUCH remarks, do not probably exceed five or six hundred feet in height. I found erratic blocks scattered widely over the whole of this country, but they were much larger and more numerous on the eastern than on the western watershed. There were also deposits of stratified sand and gravel on the heights, but I was never able to discover any shells in them, nor in the blue clay in the lower grounds bordering the lakes, except very rarely, and these were of freshwater species; as, for example, at the place before mentioned near Lake Maeler not far from Torshälla, between Smedby and Kongsör. It will naturally be asked, whether the appearance of the interior is generally such as would agree with the hypothesis of a gradual rise, according to which we must suppose that every tract has in its turn been first a shoal in the sea, and then for a time a shore. It appeared to me, on comparing both the eastern and western coasts and their islands with the interior, that the geological appearances and physical

* See HISINGER's *Anteckningar*, vol. iv. p. 42.

features of those parts of the country which I examined answered well to all the conditions of such a theory. In passing from Gefle to Fahlun, and from thence to Sala, I found the number of erratic blocks very great, as now on the islands and shores of the Bothnian Gulf; whereas on the opposite or western coast they are smaller in size and quantity, both in the interior of the country around Uddevalla and Gothenburg, and at the sea-side in the contiguous Skär. I saw some considerable boulders overlying the deposits of recent shells at Capellbacken near Uddevalla, a phenomenon analogous to that described near Upsala, where these huge erratic blocks repose upon the sand-hills, characterized by fossil shells of Baltic species. The transportation, therefore, of these rocky fragments into their present position continued after the period when the modern shelly formations of both coasts were accumulated; and it may be inferred from several facts mentioned in this memoir, that the drifting of such blocks may now be going on by means of ice every year. I am at a loss to conceive from what data some geologists have inferred the simultaneous dispersion of the erratic blocks of the North of Europe; but it would carry me into too wide a digression should I endeavour to controvert that theory. I can, however, confirm the statement of Professor HAUSMANN, that, in the ridges of sand and gravel, the largest blocks occur in the highest parts of each ridge; a fact which seems to me to point to the mode in which they may have been drifted into their present position. For if these ridges were originally sand-banks in the sea, as the marine shells found in some of them incline me to believe, the summits of such banks would have arrested the progress of ice-islands which might transport fragments of rock in the manner before suggested.

In regard to the proposition, that the land in certain parts of Sweden is gradually rising, I have no hesitation in assenting to it after my visit to the districts above alluded to. Independently of the geological proofs derived from strata containing recent shells, the evidence in favour of an upward movement consists of two kinds: first, the testimony of the inhabitants; and secondly, the altered level indicated by artificial marks cut in the rocks. More than one generation has passed away since CELSIUS recorded the stories of pilots, fishermen, and the inhabitants of the two opposite coasts at Gefle and Gulholmen respecting the increased extension of land and apparent sinking of the sea. It was at the same places that I heard precisely similar accounts from persons now living; so identical, indeed, that if related, they would appear mere repetitions of the words of CELSIUS, with scarcely any change except in the names of the witnesses. But I am aware, from what I myself experienced when reading formerly on this subject, that it is not easy to convey to the minds of those who do not visit the country, the impression made by the testimony now under consideration, deriving as it does almost all its weight from an accumulation of minute particulars, each, separately considered, of but small importance.

From what I saw at Calmar and Stockholm as compared with Oregrund and Gefle, I have no doubt that the rate of elevation is very different in different places; and in



the south of Scania I could not ascertain, either from the testimony of the inhabitants or from any appearances on the coast, that the slightest change of relative level can be detected. The difference of about three feet in a century, indicated by the mark at Löfgrundet, and of about two feet in sixty-four years, by that of Marstrand, are in such complete accordance with the results of the surveys of BRUNCRONA, HÄLLSTROM, and others, as to lead me to place entire reliance on the conclusions to which they have arrived from a larger number of data, and respecting a territory of much greater extent. The slight amount of difference between the level of the sea and the marks of 1820 which I observed at Oregrund and Gefle, although corroborating the same result, are undoubtedly in themselves of small value; and a difference of level amounting only to about four or six inches may be easily attributed to accident or the particular state of the weather at the time of my visit. Subsequent observers might find the same marks submerged beneath the waters; but I nevertheless believe, that if the summer season and a calm day be selected, so that the circumstances shall correspond with those under which the marks were originally cut, there will be found to have been a real depression of level, to the amount of several inches, in the course of the last fourteen years.

Be this as it may, I may be allowed to congratulate the scientific world that this wonderful phenomenon is every day exciting increased attention among the philosophers of Sweden, and especially of Professor BERZELIUS, who, in his reports to the Academy of Sciences at Stockholm, has already recorded many valuable observations on the levels of the water of Lake Maaler at different seasons, and who is understood to be now exerting himself to secure more frequent observations in future of the marks in the Bothnian Gulf. It is only by multiplying such measurements, and repeating them within short intervals of time, that we shall be able to determine whether the movement of the land be oscillatory or always in one direction, and whether it be intermittent or constant.

APPENDIX.

List of Fossil Shells from the Country near Stockholm.

Names.	Observations.
1. <i>Tellina Baltica</i> . Var. <i>a</i> . Pl. II. figs. 1. & 2.	The variety of this shell, found fossil in sand and marl at Solna, Bränkyrka, and Södertelje, where it is associated with littoral shells, is smaller, thinner, and deprived of epidermis, resembling those which I collected in the sand on the shores of the Gulf of Bothnia and at Solvitzborg.

- | Names. | Observations. |
|---|--|
| <i>Tellina Baltica</i> . Var. <i>b</i> .
Pl. II. figs. 3. & 4. | This variety of <i>T. baltica</i> was found in stiff blue clay between Smedby and Kongsör (see page 10), as also at Ulfva, near Upsala (see page 14). It is larger, thicker, and covered with a strong green epidermis; but there is a passage between it and the preceding variety. |
| 2. <i>Cardium edule</i> . Var.
Pl. II. fig. 6. | This <i>Cardium</i> is generally of a small size in the brackish waters of the Baltic, and often more elongated transversely than individuals of the same species in the ocean. This transverse form is seen in the fossils found at Solna and other places near Stockholm mentioned in the memoir; and Mr. GRAY tells me that the same variety has been observed elsewhere in brackish waters. But individuals of the more ordinary form, though of a dwarfish size, are also found living in the Baltic, and fossil in the localities above mentioned. |
| 3. <i>Mytilus edulis</i> . | The variety of this shell, which occurs fossil at Solna, Bränkyrka, Södertelje, Ulfva, &c., is small, about half an inch long, like that now inhabiting the brackish waters of the Baltic. It is almost always found in a state of decomposition, and converted into a violet-coloured marl. |
| 4. <i>Littorina littorea</i> . (<i>Turbo littoreus</i> , LINN.) | Found fossil at Solna, Bränkyrka, Södertelje, Skerplinge, and other places bordering the Baltic. I found varieties of different ages, but never any which approached the larger size which the same species often attains on the borders of the ocean. |
| 5. <i>Littorina rudis</i> . (<i>Turbo rudis</i> .) | A young specimen of this occurred fossil with the former at Bränkyrka; also in the violet-coloured marl from Nädendal in Finland, given me by Colonel HÄLLSTRÖM (see page 22). |
| 6. <i>Littorina crassior</i> . (<i>Turbo crassior</i>). | I found specimens of this at Solna. |
| 7. <i>Paludina ulva</i> ? Pl. II.
fig. 5. <i>a. b. c.</i> | A great number of small univalves, of which I have given figures, are found fossil with littoral shells at Solna, Bränkyrka, and Södertelje, resembling those which occur generally in the sands of the shores of the Baltic, as well as on those of the ocean between Uddevalla and Gothenburg. The three principal varieties which are figured are |

- | Names. | Observations. |
|---|--|
| | selected from the different localities of fossils before mentioned near Stockholm. In var. <i>a</i> there are five volutions, which are of a squarish form; in var. <i>b</i> five, which are rounded; and in var. <i>c</i> six, which are rounded. On comparing a great number of individuals, there appeared to be so many passages from one form to another as to render it difficult, if not impossible, to establish distinct species. |
| 8. <i>Rissoa parva</i> . (<i>Turbo parvus</i> , MONT.) | I found at Bränkyrka a few individuals which Mr. GRAY referred to this species. |
| 9. <i>Neritina fluviatilis</i> . | A small black variety of this species was met with at Bränkyrka, which I also saw recent in abundance on the shores of Möen, in Denmark. Dr. BECK, of Copenhagen, regards it as a distinct species. It is smaller than the same shell living in fresh water. I found some varieties both fossil at Bränkyrka and recent at Gräsö, near Gefle, which had the ordinary colours of the <i>N. fluviatilis</i> . |
| 10. <i>Bulimus lubricus</i> . | Fossil at Bränkyrka. (See page 6.) |

List of Fossil Shells from Uddevalla, on the West Coast of Sweden.

- | Names. | Observations. |
|---|--|
| 1. <i>Pholas crispata</i> . | I met with one valve only of this species, at Capellbacken, near Uddevalla. |
| 2. <i>Mya truncata</i> . | Found in very great abundance around Uddevalla. |
| 3. <i>Anatina myalis</i> , LAM.
(<i>Mya pubescens</i> , TURT.
<i>Ligula pubescens</i> , MONT.) | I met with one very perfect specimen, with its ligament, fossil near Uddevalla. |
| 4. <i>Saxicava rugosa</i> . (<i>Mytilus rugosus</i> , MONT.)
Pl. II. figs. 24—29. | The small individuals, figs. 28, 29., would be called by some conchologists <i>Hiatella arctica</i> ; but many naturalists are now of opinion that the shells called <i>Saxicava</i> or <i>Hiatella rugosa</i> (<i>Mytilus rugosus</i> , LINN.), and the <i>Hiatella arctica</i> , are not specifically distinct; and the fossils which I collected in great abundance at Uddevalla confirm me in this opinion. This shell is more abundant perhaps than any other, and some individuals are of great thickness, and must evidently have been very aged (see fig. 27.). I never found any of them lodged in cavities in |

Names.	Observations.
	rocks, and I presume that they must have lived in the roots of fuci, in which situation they are sometimes met with on our coast.
5. <i>Tellina triangularis</i> .	Common at Capellbacken.
6. <i>T. Baltica</i> .	I found one individual, which seems not distinguishable, in size or shape, either from the fossil or recent <i>T. baltica</i> of the neighbourhood of Stockholm.
7. <i>Astarte</i> . Figs. 17, 18.	Shell rather convex, transversely elliptical, thin; its surface strongly furrowed; furrows rounded, about sixteen. Lunette deep, elliptical. Lateral tooth slender, elongated, more transverse than the recent <i>Astarte Garensis</i> , and with somewhat fewer furrows, but perhaps a variety of the same?
8. <i>Astarte</i> . Figs. 19, 20.	Shell convex, transversely elongated, but less so than the former; both the anterior and posterior margins more rounded than in the preceding; rather thin; its surface strongly furrowed; furrows deep, rounded, about sixteen. Lunette deep, lanceolate, elongated. The lateral tooth slender. Perhaps, like the former, a variety of <i>A. Garensis</i> , to which it approaches much nearer.
9. <i>Astarte</i> . Figs. 21, 22, 23.	Shell compressed, suborbicular, slightly truncated on the posterior margin; thin; its surface rugose, marked with many transverse furrows when young. Lunette deep, lanceolate, short, pointed. Lateral tooth small, short. Fulcrum long.
10. <i>Cardium edule</i> .	
11. <i>Mytilus edulis</i> .	In great abundance, and preserving a portion of its colour; about two inches in length.
12. <i>Modiola barbata</i> .	From Kured.
13. <i>Pecten Islandicus</i> .	In great abundance, often preserving its colour, and covered with <i>Balani</i> .
14. <i>Terebratula</i> . Pl. II. figs. 32, 33.	A single perforated valve is all that I found of this genus.
15. <i>Patella</i> , allied to <i>testudinaria</i> , CHEMN. (<i>P. Clelandi</i> , Sow.) Pl. II. figs. 30, 31.	This <i>Patella</i> is referable to the genus <i>Lottia</i> , GRAY, (Philosophical Transactions, 1834.).

- | Names. | Observations. |
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| 16. <i>Patella Noachina</i> ,
CHEMN. (<i>Puncturella</i> ,
LOWE.) Pl. II. figs. 13, 14. | Mr. G. SOWERBY informs me that this species has been lately found fossil with other recent shells, at a slight elevation above the level of the sea near Glasgow. |
| 17. <i>Margarita striata</i> , LOWE.
(<i>Trochus</i> , LAM.) | |
| 18. <i>Littorina littorea</i> . (<i>Turbo littoreus</i> , LINN.) | Some young individuals at Uddevalla retain their colour in great perfection. |
| 19. <i>Littorina</i> ? Plate II.
fig. 10. | The shell here figured has lost its outer coat, and may perhaps belong to the genus <i>Littorina</i> . |
| 20. <i>Turritella</i> ? Plate II.
figs. 11, 12. | This shell is very like a worn <i>Scalaria</i> , but perhaps belongs to the genus <i>Turritella</i> . |
| 21. <i>Natica</i> , allied to <i>N. clausa</i> . Pl. II. figs. 7, 8, 9. | This shell is common at Uddevalla, especially at Kured, and differs decidedly from the <i>N. glaucina</i> , having a less flattened spire, and being more ventricose, I presume that it is the <i>N. glaucina</i> of Mr. HISINGER's list of Uddevalla shells. |
| 22. <i>Velutina</i> , GRAY. Pl. II.
figs. 15, 16. | Probably <i>Helix lævigata</i> , MONT. An imperfect specimen. |
| 23. <i>Fusus</i> . (<i>Murex rumphius</i> , MONT.) | Very common. |
| 24. <i>Fusus corneus</i> . | |
| 25. <i>Buccinum undatum</i> . | Abundant. |
| 26. <i>Balanus sulcatus</i> . | Very abundant, and of large size, and occurs both attached to other shells and fixed to the rocks of gneiss. (see p. 25.) |
| 27. <i>Balanus tulipa</i> . (<i>Lepas tulipa</i> , MULLER, CHEMNITZ, viii. t. 92. f. 832.)
Pl. II. figs. 34, 35, 36, 37, 38, 39. | Mr. GRAY informs me that this shell is not noticed by LAMARCK, and that it differs from other <i>Balani</i> in the substance of the shells being solid, and the base being only longitudinally grooved on the inner side; also in the side edges of the valves being entire and not crenulated. By the aid of these characters Mr. GRAY has formed of this and a few other species which are in the collection of the British Museum, a particular section, to which he has given the name of <i>Chirona</i> . This I presume is the species called <i>B. Uddevallensis</i> in some of the Swedish lists of Uddevalla fossils. It is of great size, frequently three or four inches long. The supports, figs. 38 and 39, were found adhering in great numbers to the face of the |

Names.

Observations.

rocks of gneiss, and they appeared to me, from their large size, to belong to this species.

28. *Echinus*. (*Echinometra*.) Pl. II. figs. 40, 41. Fragments of this *Echinus* were found at Capellbacken near Uddevalla, and they have been put together as represented Plate II. figs. 40, 41.

This collection of Uddevalla fossils must be very incomplete, as they are only such as I could obtain by diligent search, and with assistance, in one day. I did not meet with *Pileopsis Ungarica*, but Mr. HISINGER showed me specimens of that shell which he obtained there.

Description of the PLATES.

PLATE I.

Map of part of Sweden, to indicate the principal localities referred to in the preceding paper.

PLATE II.

Figs. 1, 2. *Tellina Baltica*, var. *a*, from Solna, Bränkyrka, and Södertelje. (See Appendix, p. 33.)

3, 4. The same, var. *b*, from Ulfva. (Appen. p. 34.)

Fig. 5. *Paludina ulva*?, three varieties, from Solna, Bränkyrka, and Södertelje. (Appen. p. 34.)

6. Transverse variety of *Cardium edule*, from Solna. (Appen. p. 34.)

Figs. 7, 8, 9. *Natica*, allied to *N. clausa*, from Kured. (Appen. p. 37.)

Fig. 10. *Littorina*? of which the outer coat is lost. (Appen. p. 37.)

Figs. 11, 12. *Turritella*? (Appen. p. 37.)

13, 14. *Patella*, LAM. (Appen. p. 37.)

15, 16. *Velutina*. (Appen. p. 37.)

17, 18. *Astarte*. (Appen. p. 36.)

19, 20. *Astarte*. (Appen. p. 36.)

21, 22, 23. *Astarte*. (Appen. p. 36.)

24, 25, 26, 27, 28, 29. *Saxicava rugosa*, from Uddevalla. (Appen. p. 35.)

30, 31. *Patella*. (Appen. p. 36.)

32, 33. *Terebratula*. (Appen. p. 36.)

34, 35. Large valves of *Balanus tulipa*, from Uddevalla. (Appen. p. 37.)

36, 37. Opercular pieces of the same. (Appen. p. 37.)

38, 39. Supports of the same.? (Appen. p. 37.)

40, 41. *Echinus* (*Echinometra*), from Capellbacken. (Appen. p. 38.)